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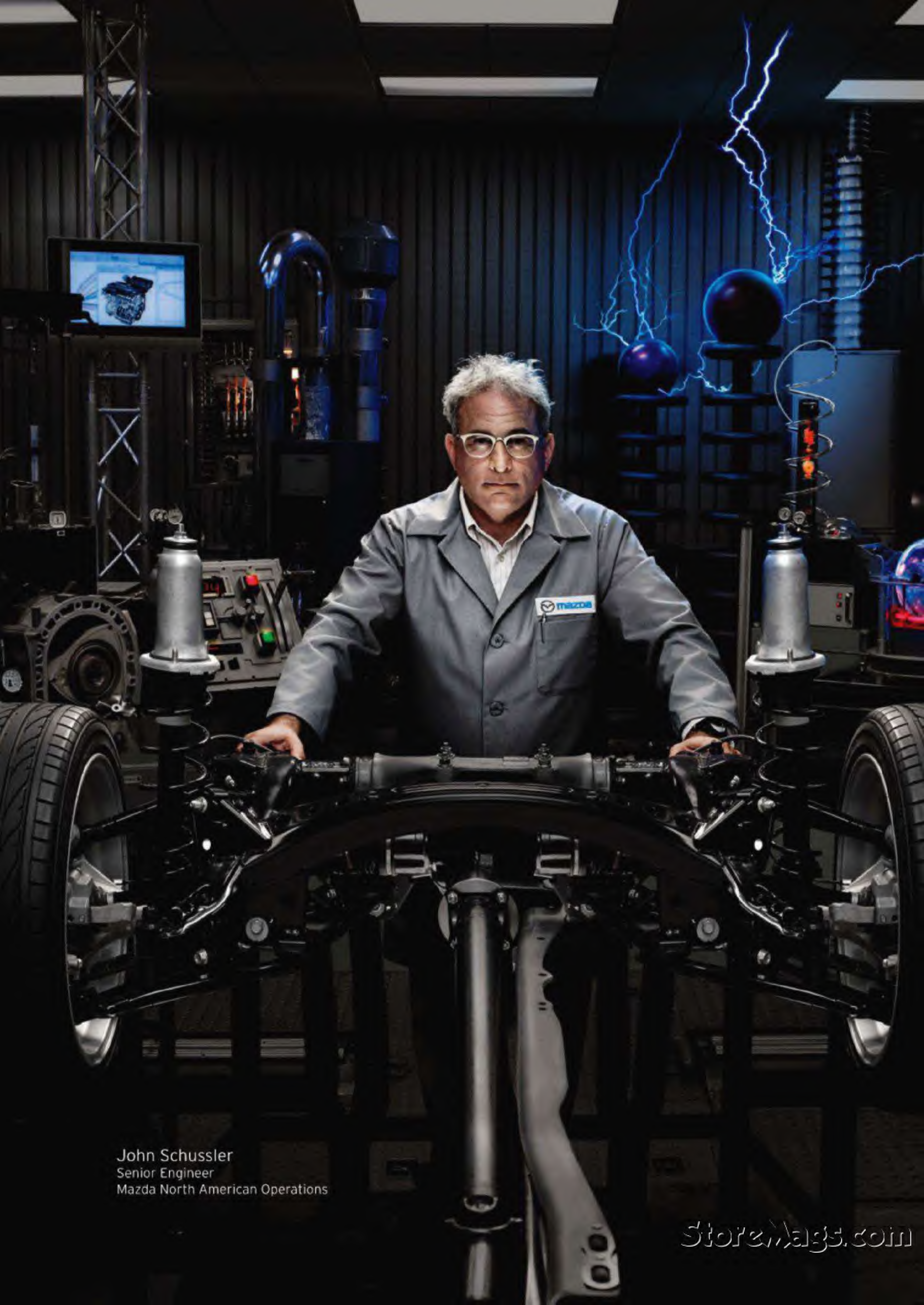
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John Schussler
Senior Engineer
Mazda North American Operations

IF IT'S NOT BROKEN... FIX IT.

For over 90 years, an obsession has pushed us to keep improving how our cars look, how they drive and how they make you feel behind the wheel. It's in our DNA. It drove us to successfully engineer our revolutionary rotary engine, and it's driven us to reimagine the automobile as a whole today.

Our goal? Ultimate efficiency. Achieve the unheard of, where fuel economy, low emissions and outstanding driving performance coexist in cars accessible to everyone. Pulling it off meant starting with a clean slate, not just carrying over old parts—and old ideas. It meant starting from the ground up and rethinking everything to work together in unprecedented harmony. We call it SKYACTIV® TECHNOLOGY.

Imagine an engine that pushes the boundaries of engineering, delivering 15% more low end torque, yet 15% better fuel efficiency, by running the compression ratio of a Formula 1 race car, all while sipping 87 octane fuel. Imagine an automatic transmission so smart it perfectly rev-matches downshifts faster than a dual-clutch transmission, while also improving fuel economy by an additional 4%. Imagine entirely new bodies 220 pounds lighter, yet stiffer and stronger than the bodies they replace. We imagined it all and more, and then we made it a reality.

Experience the first step of this reality with the new SKYACTIV®-G engine and SKYACTIV® transmissions in the new Mazda3, then look for the evolution of SKYACTIV® TECHNOLOGY with every new Mazda going forward.

Reimagining the automobile wasn't the goal, it just ended up that way. But that's who we are, and that's what we do. Because for us, if it's not worth driving, it's not worth building.

Learn more about SKYACTIV® TECHNOLOGY at MazdaUSA.com/skyactiv

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What do you drive?

zoom-zoom



Changing the Future of Driving Forever

SKYACTIV[®] TECHNOLOGY



SKYACTIV is a registered trademark of Mazda Motor Corporation.

Given the increasing number of digital systems under the hood and inside the passenger cabin, automobiles today resemble computers on wheels. With each model year, vehicle manufacturers offer more sophisticated electronic systems addressing vehicle safety, telematics and infotainment. In addition to enhancing vehicle electronics, Mazda is single-handedly leading the charge in another key area—one that will change the future of driving forever.

Mazda realized that 10 years from now the internal-combustion engine (ICE) will still power the majority of vehicles. Even hybrids use them. However, the current ICE is only about 30 percent efficient, with 70 percent of the energy in the fuel going to waste. If you start fresh and refuse to accept the compromises other manufacturers have accepted for 100 years, you'll see there's room for improvement.

So, Mazda turned their focus to improving the efficiency of the ICE to make the greatest impact. Plus, today's high-mpg vehicles are lacking in the fun department. Mazda finds this unacceptable, so they reimagined the car to deliver a surprising combination of improved performance and increased fuel efficiency across their entire product lineup. They call it SKYACTIV TECHNOLOGY. Here's how they did it and what it means to you.

SKYACTIV-G

- 15% better fuel economy
- 15% improvement in torque
- Lightweight, lively throttle response

ENGINE

Most automakers attempt to boost engine performance by simply adding turbochargers to force more air into the combustion chamber. Mazda, however, chose to re-examine how fuel is burned, with the goal of making the engine more efficient. The solution? A redesigned exhaust manifold that removes residual gases more efficiently, keeping temperatures and pressure in the combustion chamber stable. And instead of a single-hole direct injection method, Mazda developed a six-hole system that distributes fuel into the combustion chamber more evenly, as well as new piston cavities that allow the fuel to burn more efficiently. The result is a lighter engine with a high compression ratio of 13:1, comparable to a Formula One racing car, marked by improved thermal efficiency and, thus, fuel economy.

TRANSMISSION

Additional gains in fuel economy were achieved when Mazda's engineers set out to design SKYACTIV-Drive with the best attributes from both a conventional automatic transmission—ease and comfort—and a dual-clutch transmission (DCT)—connected efficiency. To do this, they first focused on improving the torque converter, which transfers engine power to the transmission through fluid, enabling smooth startups and gear shifting. Their solution was to develop a torque converter with a lock-up clutch, which locks the torque converter's turbine to the impeller to improve

SKYACTIV-Drive

- Improved fuel economy (+7%)
- Quick, smooth shifting and directly connected feel
- Smooth, easy launch control

fuel economy and direct-drive feel. And, when the transmission is first assembled, the transmission control module learns the behavior of each of its shift signalers,

so it knows exactly how this transmission will respond to every signal it might send. Mazda's decision to merge the best of both worlds through very sophisticated technology led to an automatic transmission so smart it perfectly rev-matches downshifts faster than a dual-clutch.

BODY

Additional gains came from the extensive use of high-tensile steel that's stronger, lighter and harder-working than conventional steel, as well as streamlined geometry such as crash-energy pathways that take advantage of

SKYACTIV-Body

- 30% increase in rigidity
- Top crash safety performance
- 8% weight reduction

the entire body instead of just the floor. Reducing the weight also helped to improve handling, efficiency, acceleration and braking. Mazda's goal of shaving 220

pounds from each new car essentially put every part of the car on a "diet." To do this, Mazda started with a clean slate versus carrying over old ideas and parts. They started from the ground up, rethinking everything at the same time—engine, transmission, chassis and body—to create an all-new design and deliver improved performance and increased fuel efficiency.

CHASSIS

Mazda engineers then set out to create a chassis that makes the vehicle more agile and stable, enabling the driver to enjoy the best of both worlds at any given speed. In fact, the same group that designed the body designed

the chassis, so neither aspect was compromised to accommodate the other. In order to accomplish these objectives, engineers elected to create a chassis that features new suspension

SKYACTIV-Chassis

- Better agility at low speeds
- Greater high-speed stability
- Excellent ride comfort
- 14% weight reduction

geometry, providing better steering and high-speed stability. The result? More rigidity and less weight amplify performance and handling.

SKYACTIV Realized

SKYACTIV TECHNOLOGY proves that driving performance and fuel efficiency don't have to be mutually exclusive. It also makes the magic number of 40-mpg highway a reality driving in the revamped Mazda3 this fall. That means customers get a vehicle that has great styling, handles like a true sports car and is easy on the environment. The all-new CX-5 will be available with SKYACTIV TECHNOLOGY in 2012. With SKYACTIV TECHNOLOGY—the new standard for all future vehicles—Mazda will realize a 30 percent gain in fuel efficiency in vehicles sold worldwide by 2015 versus the vehicles sold in 2008. Mazda intends to offer a diesel version of its new engine and foresees the use of SKYACTIV TECHNOLOGY in future hybrid and electric models. Meanwhile, as internal-combustion engines will be with us for

a while longer, Mazda is also keen on making one that is environmentally sound and makes a car fun to drive.



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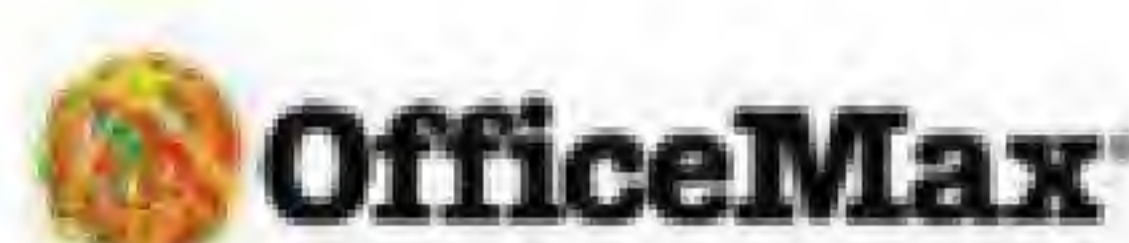
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Behold the guts
of what will soon
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the Blue Gene/Q.



On
the
cover

66 X-Plane Rising After 100 years of sending pilots skyward, the U.S. Navy prepares to unleash its most advanced warplanes ever—with robots in control. At this pivotal moment in naval aviation, PM assesses how the cutting-edge X-47B and Phantom Ray stack up against their piloted competitors. **BY JOE PAPPALARDO**

76 We're Throwing Away Energy ... Car engines, electrical power conversion, even human movement—they all waste energy. How can we capture and use it? PM surveys the latest designs and technologies that target everyday inefficiencies to put runaway watts to work. **BY ALEX HUTCHINSON**

82 The 2000-MPH Dream On Oct. 15, 1997, a car with twin Rolls-Royce jet engines and a massive support team set the current land speed record of 763 mph. Today, Waldo Stakes toils alone in a Mojave Desert warehouse, piecing together a vehicle that he says will go more than twice as fast. **BY JOHN PEARLEY HUFFMAN**

86 Super Computer Chip by chip, rack by rack, IBM engineers are building the world's most powerful computer. It will change the math on everything from weather prediction to nuclear simulations and reassert America's technological dominance. Here, an exclusive look inside the Blue Gene/Q. **BY GLENN DERENE**

It's the centennial of U.S. naval aviation, but a robot—not a pilot—may own the future. Able to reach high subsonic speeds, the X-47B unmanned aerial vehicle is vying for primacy against piloted aircraft. The X-47B's first carrier landing is planned for 2013.

PHOTOGRAPH BY **IAN ALLEN**

Tech Watch

15 Sailing on Sunshine The world's largest solar-powered boat nears completion of its round-the-globe trip. **Plus:** Self-inflating tires, mood-altering bacteria and two robots—one rescues miners, the other helps astronauts.

Upgrade

29 2012 Wish List Holiday shopping is a no-brainer with our roundup of tools, toys and gadgets. From the Thing-O-Matic 3D printer to the Bosch 18-volt Gen 2 Brute drill, PM presents the best stuff. **Plus:** Win \$3500 in swag!

New Cars

47 Auto Excellence Awards 2012 After testing hundreds of vehicles in a year's time, the PM auto experts pick the top 10, from most efficient to best performer.



Jetlev R200 chief pilot Steven J. Grey levitates on aquatic pillars created by the hydropowered device.

The Jetlev is different. Not only is it a remarkably successful piece of engineering, but the experience it offers is the most exhilarating thing I've tried since surfing. — I'll Try Anything, "Jetpack at Last," page 64

Column

64 I'll Try Anything: Jetpack at Last Seems reality has finally caught up with science fiction. Senior correspondent Jeff Wise finds out firsthand: The Jetlev R200 is a total blast.

On
the
cover

47 The Top 10 Cars of 2012 **29 Win \$3500 in Gear**
66 America's Next Warplane **86 World's Fastest Computer**

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Tech

90 Cellphone Cinematography Getting pretty great video from a not-so-great camera.
95 Digital Clinic Retrofit your old printer to utilize the cloud. **Plus:** Websites that turn everyday tasks into games that motivate.



Home

98 Drill Team The 12-volt drill is small, powerful and cheap. No wonder it's so popular! We test 13 to lighten your load.
103 Homeowners Clinic How to find your flashlight when you need it most: in the dark. **Plus:** Make your own drill holster.
108 How Your House Works: Fireplace Learn how the flue, smoke shelf and refractory brick keep a hearth crackling.
112 PM Saturday Our DIY Christmas stocking holds 50 pounds of gifts. Give, Santa!



Auto

115 The Myth of the All-Season Tire We compare the year-round tire with the snow tread in a four-point test and show why you should consider swapping in winter rubber.
118 Car Clinic How to fix your car's noisy valves after storage. **Plus:** Smooth over windshield scratches; three tools to make tricky jobs easier.

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PHOTOGRAPH BY FILIP KWIATKOWSKI

LONG LIVE THE SPLASH



LONG LIVE IMAGINATION
What will you imagine with the EOS 7D
and EF lenses? Long Live Imagination.



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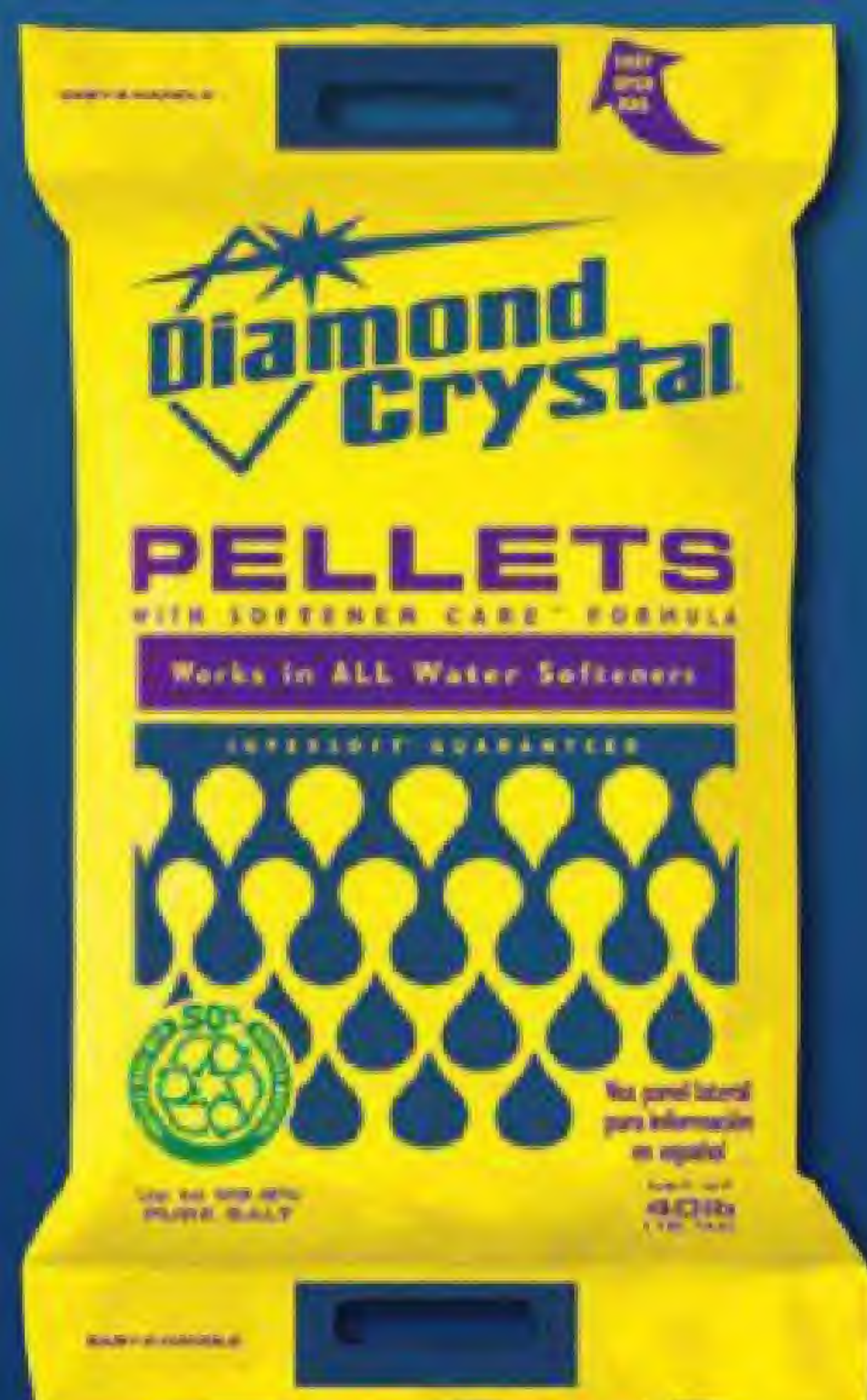


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INSIDE THE NFL BRAIN BANK In a small lab in Boston, researchers are examining the donated brains of deceased athletes to understand the damage that professional football players sustain from repeated blows to the head. PM got an inside look at the research.

popularmechanics.com/nflbrains



8 INSANE INSTRUMENTS Music has always fascinated engineers and tinkerers. We found some of the wildest inventions in the world, including a phonograph you can play like an instrument and the water-powered hydraulophone.

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5 REASONS TO LOVE VAMPIRE BATS They have a scary name and, yes, they do suck blood. But vampire bats are also amazing animals with supercharged senses and complex social networks—and they just might hold the key to important new drugs for humans.

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For PM reader Karl Frei, of Turin, N.Y., facilitating cargo movement for Raytheon Polar Services in Antarctica means limited contact with the outside world. He stays current with PM. "I love POPULAR MECHANICS for articles on the newest technology being put to present-day use," he says.

motorcycle road trip was outstanding, and, in general, your articles are timely, informative, interesting and, in many cases, not found elsewhere. Thanks for one of the best magazines out there today. **CLARK ROBBINS** WHITE LAKE, MI

Reader Recipes

After reading your article "Invasive Species? If You Can't Beat 'Em, Eat 'Em" (October), I thought about our own problem here in Lake Tahoe. We have a plant called water milfoil that's taking over the marinas and spreading into our precious lake. Not sure if I want to be the first one to make a salad out of it, but if it's deemed safe to eat, I just might pair it with some sushi or bake it. I wonder if anyone's done a study on this plant. All I know is that a lot of money is being spent in attempts to eradicate the stuff.

STEVE RICOLI SOUTH LAKE TAHOE, CA

On the Road Again

I really enjoyed reading about your adventure-touring motorcycle ride into Michigan's Upper Peninsula ("Good to Go," October) and, I have to admit, I am quite jealous! I'm more of a four-wheeler guy, but I'm always looking for new places to ride. Would some of those trails your test crew rode be open to a quad? Obviously I couldn't follow your road route on one, but some of those off-road trails sound incredible. Thanks for the story, and keep up the great work!

DREW METZGER GOSHEN, IN

EDITOR'S NOTE: Most of the trails we rode would be perfect for a four-wheeler. But we only scratched the surface—Michigan has more than 3200 miles of off-road trails. The state's Department of Natural Resources posts detailed maps on its site, michigan.gov/dnr. Take a look, pick a route and ride safe! **LARRY WEBSTER** AUTOMOTIVE EDITOR, POPULAR MECHANICS

POPULAR MECHANICS is getting better and better! Your recent article on the

I enjoyed your story on invasive species. I just moved back to the States after living in Puerto Rico for 17 years. There's a serious problem there with big green iguanas. I don't know when they first arrived on the island, but the reptiles are now in residential areas of most cities along the north coast. It's common to see dozens of them as roadkill—or about to become roadkill. Some restaurants try to trap and grill them, but I don't think it's catching on. I'd love to see PM do a follow-up piece. **EDDIE COLON** STATEN ISLAND, NY

From our fans
and followers



Hello, PM readers on Facebook and Twitter—and thank you for responding to our stories. Here are some recent comments:

Great DIY aircraft article in @PopMech. Everyone should design and fab a twin 2500-hp contra-rotating piston prop.
@HENRIK82, VIA TWITTER ("DIY Flight," October)

Interesting read on the phaseout of incandescent bulbs for CFLs. I *hate* CFLs.
@AJIMHOLMES, VIA TWITTER

("Is the Light Bulb Ban a Bright Idea?" popularmechanics.com)

Brightens my day when I get a new @PopMech magazine. :D
@AJBUETTNER, VIA TWITTER

I want one to go to school in the morning!!!
ARTHUR SCHMIDT, VIA FACEBOOK ("ApocalypseEV-1: The Electric Car for the End of the World," popularmechanics.com)

"Build Your Own Plane"—Again a stylish cover, POPULAR MECHANICS.
@COVERJUNKIE, VIA TWITTER (October)

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Stars Shine at PM Celebration

ON OCT. 10, PM'S BREAKTHROUGH AWARDS BROUGHT THE YEAR'S MOST INNOVATIVE MINDS TO THE HEARST TOWER FOR OUR SEVENTH ANNUAL SALUTE TO SCIENCE, TECHNOLOGY, AND ENGINEERING.

[1] Inventor, explorer, and filmmaker James Cameron was honored with the Breakthrough Leadership Award for, among other things, creating the 3D camera system that brought *Avatar* to the screen. Accepting the award, he reflected on PM's influence on his childhood—and urged the audience, “now get up off your ass and go make something!”

[2] AeroVironment's Matt Keennon, left, flies his Nano Hummingbird robot for Sigourney Weaver and editor-in-chief Jim Meigs.

[3] Garrett Reisman, left, two-time shuttle astronaut and head of SpaceX's Dragon Rider program, discusses manned spaceflight with DARPA's Todd Hylton.

[4] The West Philly Hybrid X team's biodiesel GTM kit car gets 100 mpg on the highway. Its high school engineers received a standing ovation.

[5] Meigs, left, and PM publisher Bill Congdon, far right, welcome Weaver, president of Hearst Magazines David Carey, and Cameron.

[6] ABSMaterials co-founder Paul Edmiston demonstrates his revolutionary water-cleaning technology, Osorb, for guests. Knob Creek and motor oil? Now that's a PM party.

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Release: StoreMags & FantaMag

• QUICK HITS



Pipe Patches

➔ A University of Arizona engineering professor is borrowing tactics from cardiologists by using the civil engineering equivalent of a stent to fix leaking pipelines. The Gas Technology Institute recently completed a series of natural gas line tests on PipeMedic, which relies on a new "superlamine" material made of crisscrossing carbon fibers with thin layers of glass fabric embedded in resin. A coil of the flexible superlamine is wrapped around a device that rolls hundreds of feet along the pipeline until it reaches the broken pipe. A balloon inflates to press the laminate into place—holding it there until the epoxy dries—and then it deflates, putting the pipe back in service.



Gem of a Planet

➔ Using telescopes in Australia, Hawaii and England, an international team of astronomers has identified a planet that has more mass than Jupiter but is only half as big. Scientists say this extreme density probably means it's made mostly of crystalline carbon—in other words, diamond—and oxygen. It's 4000 light-years away, so mining companies won't be visiting there soon.

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• PV PANEL
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• PV POWER:
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Car Talk

➔ Nearly 3000 cars, trucks and buses will soon be "speaking" with the roads of Ann Arbor, Mich., as part of a \$14.9 million test of vehicle-to-infrastructure communication. Staff at the University of Michigan Transportation Research Institute will equip the vehicles with devices that broadcast their direction and speed via short-range radio. The researchers will also monitor nearly 400 vehicles fitted with receivers that will alert drivers if any other participating vehicles are approaching in an unsafe manner. The results of the 12-month trial will help the U.S. Department of Transportation evaluate possible regulations requiring the installation of connected-vehicle technology in new cars after 2013. —A.H.

NEWS + TRENDS + BREAKTHROUGHS



Tech Watch



• ALTERNATIVE ENERGY

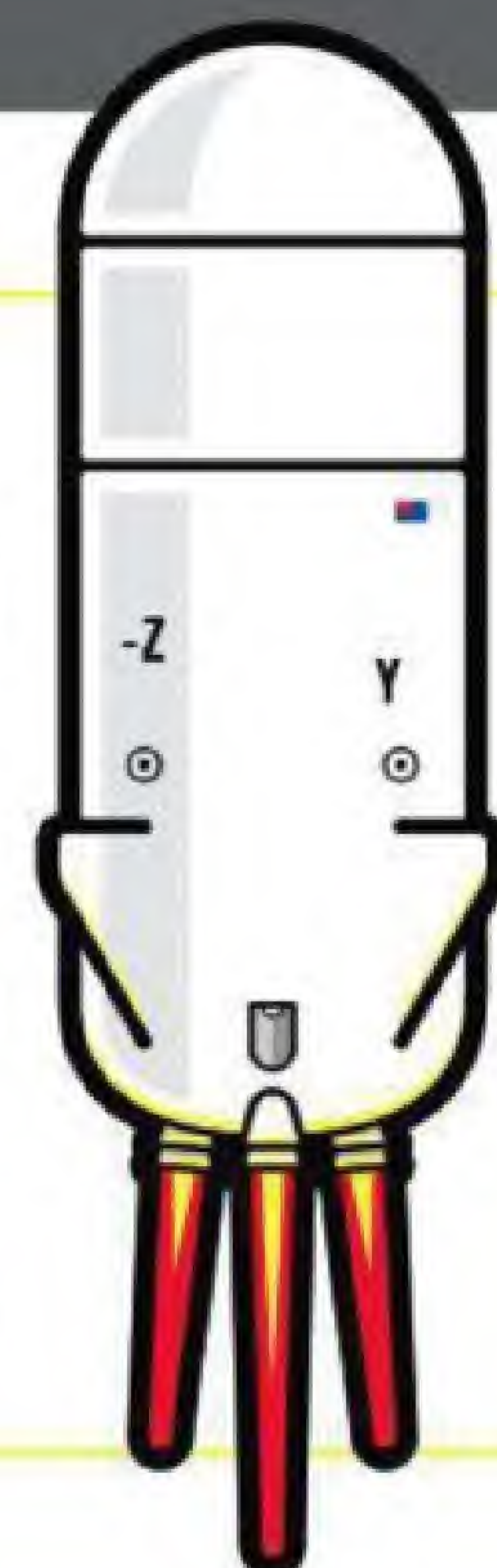
Sailing on Sunshine

A solar-powered catamaran that left Monaco in September 2010 is on schedule to complete its round-the-world cruise—the first fully solar-powered circumnavigation of the globe—in May 2012, if all goes according to plan. The *MS Tûranor PlanetSolar* produces five times the power needed to propel the vessel, filling a battery that provides power at nights, on cloudy days and for auxiliary needs such as water desalination. Of course, the trip isn't the first globe-spanning odyssey to rely on renewable energy: Ferdinand Magellan's crew finished the circumnavigation in 1522 in a ship powered by wind. —ALEX HUTCHINSON

• PRIVATE SPACE RACE

Secret Spacecraft Comes Down to Earth

S➔ Secretive space firm Blue Origin, founded by Amazon.com CEO Jeff Bezos, was forced into the public eye when one of its experimental craft crashed in West Texas in late August. The unmanned spacecraft self-destructed after it lost control at 45,000 feet. "[It was] not the outcome any of us wanted," Bezos wrote on Blue Origin's website. The company is researching ways to enable spent booster engines to fly back to the ground and land vertically so that they can be reused. Modern boosters drop into the ocean and must be recovered by ships; private space companies hope to find big savings by having the used engines fly home on their own. —Joe Pappalardo



IT'S NOT THE FIRST HYBRID. BUT IT MIGHT BE YOURS.

Admit it. Hybrids have never seemed right for you. Maybe you just never saw yourself as a hybrid type, thinking that you have to practice hot yoga, wear hemp clothing and eat tofu to drive one.

At Hyundai, we were a little skeptical of hybrids ourselves. Maybe, like us, you didn't want to sacrifice anything in order to drive one. Like comfort, power or style.

Then along came the uniquely advanced lithium polymer battery. And, with it, the opportunity to build a new kind of hybrid.

A battery we can believe in.

The lithium polymer battery is a real breakthrough in a number of ways. Instead of requiring a bulky, rigid casing, it uses a flexible polymer that takes up 40% less volume. It has 25% less weight and 10% greater efficiency compared to conventional nickel-metal hydride batteries in other hybrids. It also helps power the Sonata Hybrid's electric-only mode up to 74 mph before engaging the fuel system. Hyundai is the first to offer it in a non-plug-in hybrid.

You don't have to sacrifice.

And while most hybrids are built with aerodynamics in mind, we believe that technology can influence aesthetics as well. So our engineers worked with the styling we put into our Sonata to produce a 0.25 drag coefficient, tied with only the Prius for the best in the industry. But turning heads is a whole lot more satisfying when you've also got more passenger volume and better highway MPG than any other vehicle in its class, with our proprietary 6-speed transmission and a class-leading 206 net hp. And we back it up with our Sonata Hybrid System Limited Warranty.

It's smart to have waited.

Many hybrids have come before the Sonata Hybrid. It's far from the first. But it's the first to measure up to the standards we think you deserve in a hybrid. And by using advanced technology to build a stylish car that's also better for the environment, who knows? We just might have made it your first hybrid, too.

For more, visit HyundaiSonata.com



The Sonata Hybrid  **HYUNDAI** NEW THINKING. NEW POSSIBILITIES.

• ROBOT SUPERHEROES

Built Tough to Go Deep

Accidents, mostly gas explosions in coal mines, killed 71 U.S. miners in 2010. Collapsed mines are dangerous for rescuers, making robots ideal first responders. But it takes a rugged machine to survive an underground emergency. The 190-pound Gemini-Scout Mine Rescue Robot, designed at Sandia National Labs, is built for the job. The Mine Safety and Health Administration may deploy the bot in 2012.

—ALEX HUTCHINSON



EXTRASENSORY PERCEPTION

GAS SENSORS AND A THERMAL CAMERA CAN DETECT IMPERILED MINERS.

SUPERHUMAN STRENGTH

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EASY TO RELATE TO

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IMPERVIOUS TO DAMAGE

ELECTRONICS ARE HOUSED IN WATERPROOF CASINGS TO PREVENT METHANE GAS EXPLOSIONS.



• 21ST-CENTURY MEDICINE

Microbial Mind Control

➔ **Can tiny organisms in our bellies control our emotions?** Researchers at McMaster University in Hamilton, Ontario, have demonstrated how bacteria in the stomach can alter the mood of mice. Researchers fed mice a strain of *Lactobacillus rhamnosus*, a probiotic bacterium, then monitored their behavior to gauge anxiety levels. "These tests rely on the conflict between the urge of the mouse to explore a novel environment and its tendency to avoid potentially dangerous areas, such as open or brightly lit spaces," assistant professor Paul Forsythe, one of the researchers involved with the study, says. "Anxious mice forgo exploring in favor of staying safe." The mice with high levels of the bacteria in their guts proved more intrepid. When the researchers snipped the vagus nerve, which connects the brain and stomach—the nerve sends a signal to the brain to be more receptive to a chemical that influences calmness—mice with high bacteria levels were timid. This pinpointed the mind-belly connection. Forsythe says he's optimistic that his research will lead to therapeutic use in humans. That doesn't mean anyone should use probiotics to try to relieve anxiety, especially since the strain he tested is not commercially available. "Until they have been tested, it is impossible to say if over-the-counter probiotics would have the same effect," Forsythe says. "The effects are very strain-specific. One type is not the same as another." —AMIR KHAN

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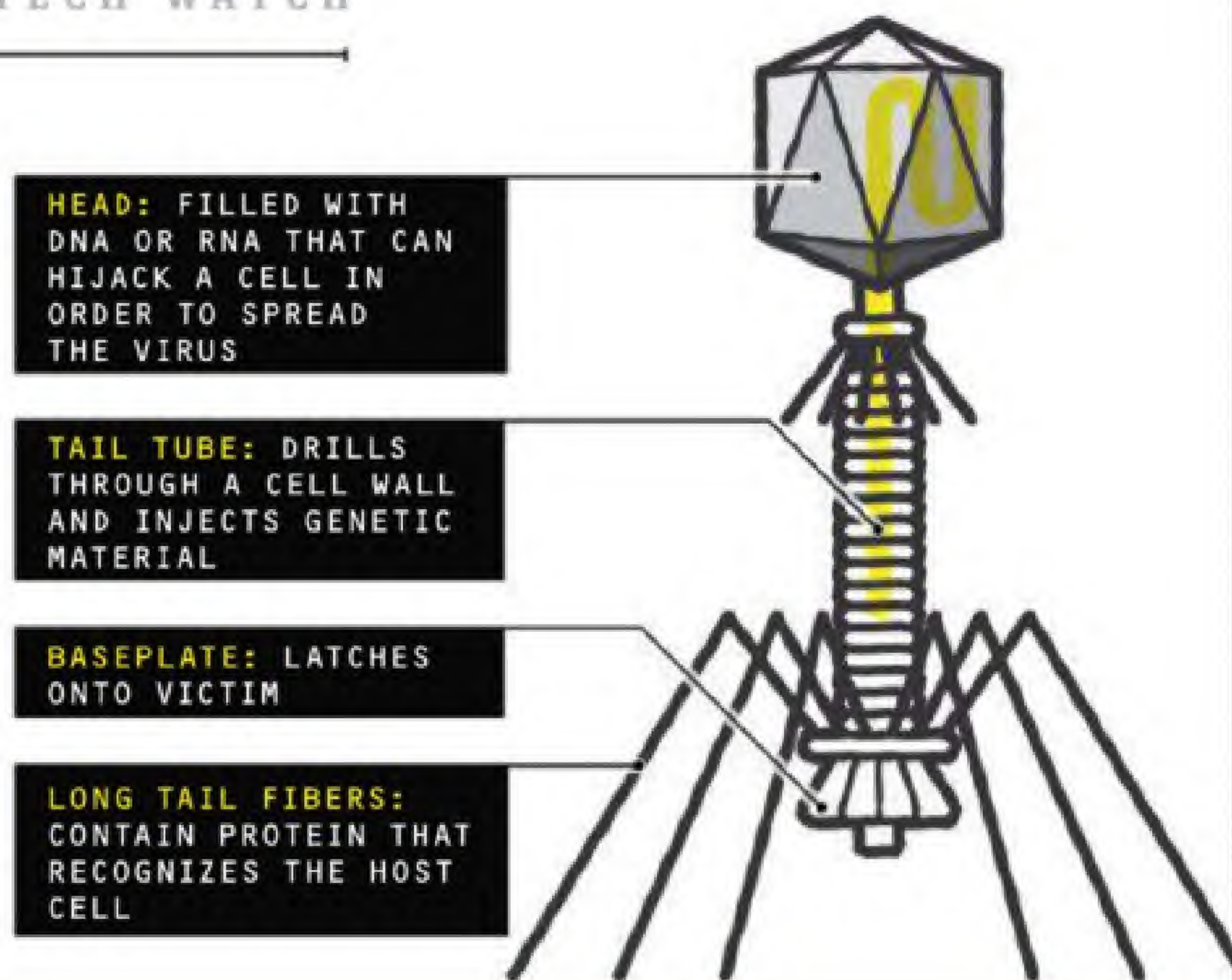
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• UNSEEN WORLDS

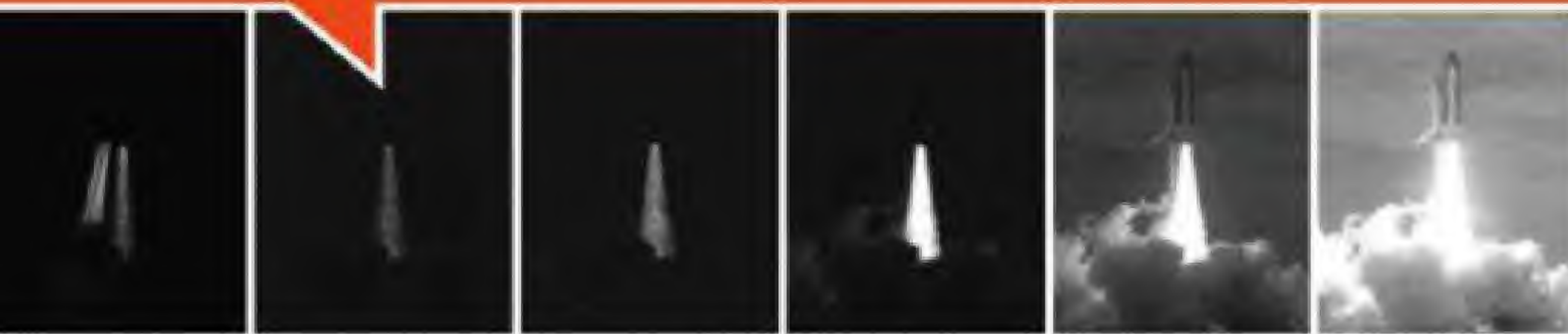
Multi-Tool Tails

→ Scientists have long known that viruses spread in an organism by injecting material into individual cells, using the host to replicate its own genetic material. But exactly how a virus invades and takes control has been a mystery—until now. Medical researchers in Japan have discovered that certain viruses use a protein on their tail as a multifunctional tool—the biochemical equivalent of a Swiss Army Knife—to penetrate cells. First, a virus rotates its screw-shaped tail like a drill bit, puncturing the cell's membrane. The tail then thrashes to clear away organic debris and enlarge the hole, allowing the virus to inject its own DNA or RNA. —ALEX HUTCHINSON



• ROCKET SCIENCE

Blinded by the Bright



NASA engineers captured the dynamics inside the engine plume of the final space shuttle launch by synthesizing six layers of images.



R

→ **Rocket launches** create a fiery spectacle, but they also create problems for NASA engineers who want to see exactly what happens when the engines ignite. A complete view of a rocket exhaust provides details of thermal and physical dynamics that can be used to create high-fidelity computer models. The fury of blastoff,

however, shrouds the scene in exceedingly bright flames and obscuring smoke.

Now, with a clever six-camera setup called Walle, NASA has found a way to see into a rocket plume or any other brilliant blast. The system merges the clearest pixels of images taken by six cameras; the combined shots offer a superhuman view of the trickiest high-contrast scenes. Walle's creators at NASA's Ames Research Center built it from spare high-speed cameras. When Walle starts recording video, one camera properly exposes the dimmest parts of a scene, leaving the brighter parts blown-out white. The next camera uses a filter to capture brighter parts of the image the other camera couldn't. The

remaining cameras use a series of increasingly dark filters until all bright and dark sections are properly exposed. Software then strips out the jet-black and pure-white pixels in each of the six sets and fuses the correctly exposed portions into one shot.

But Walle is capable of much more than stunning visuals. It might also record high-contrast explosions to capture images of chunks of shrapnel inside the blast that are too dim for regular cameras to see. Another potential use: to record the exposure of materials to searing-hot plasma inside an arc jet, a device used to simulate the heat of atmospheric reentry.

—DAVE MOSHER

ICE BRAKER

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and for more information about PRADAXA call 1-877-PRADAXA or visit pradaxa.com.

 **Boehringer
Ingelheim**

*Here's why you should ask your doctor about **PRADAXA**.*

- In a clinical trial, PRADAXA 150 mg **reduced stroke risk 35% more than warfarin.**
Risk reduction was greatest when compared to patients on warfarin whose blood tests showed lower levels of control.
- **Unlike warfarin, no regular blood tests.**

PRADAXA is a prescription blood-thinning medicine used to reduce the risk of stroke and blood clots in people with atrial fibrillation not caused by a heart valve problem. With atrial fibrillation, part of the heart does not beat the way it should. This can cause blood clots to form, increasing your risk of a stroke. PRADAXA lowers the chance of blood clots forming in your body.

IMPORTANT SAFETY INFORMATION ABOUT PRADAXA

PRADAXA can cause bleeding which can be serious and sometimes lead to death. Don't take PRADAXA if you currently have abnormal bleeding or if you have ever had an allergic reaction to it. **Your risk of bleeding with PRADAXA may be higher if you:** are 75 years old or older, have kidney problems, have stomach or intestine bleeding that is recent or keeps coming back or you have a stomach ulcer, take other medicines that increase your risk of bleeding, like aspirin products, non-steroidal anti-inflammatory drugs (NSAIDs) and blood thinners.

Call your doctor or seek immediate medical care if you have any of the following signs or symptoms of bleeding: any unexpected, severe, or uncontrollable bleeding; or bleeding that lasts a long time, unusual or unexpected bruising,

coughing up or vomiting blood; or vomit that looks like coffee grounds, pink or brown urine; red or black stools (looks like tar), unexpected pain, swelling, or joint pain, headaches and feeling dizzy or weak.

It is important to tell your doctor about all medicines, vitamins and supplements you take. Some of your other medicines may affect the way PRADAXA works.

Take PRADAXA exactly as prescribed by your doctor. Don't stop taking PRADAXA without talking to your doctor as your risk of stroke may increase.

Tell your doctor if you are planning to have **any** surgery, or medical or dental procedure, because you may have to stop taking PRADAXA for a short time. PRADAXA can cause indigestion, stomach upset or burning, and stomach pain.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch or call 1-800-FDA-1088.

Please see more detailed Medication Guide on next page.

Reduce your risk of a stroke caused by a clot that starts in the heart.

Pradaxa[®]
dabigatran etexilate
CAPSULES

Read this Medication Guide before you start taking PRADAXA and each time you get a refill. There may be new information. This Medication Guide does not take the place of talking with your doctor about your medical condition or your treatment.

What is the most important information I should know about PRADAXA?

- PRADAXA can cause bleeding which can be serious, and sometimes lead to death. This is because PRADAXA is a blood thinner medicine that lowers the chance of blood clots forming in your body.
- **You may have a higher risk of bleeding if you take PRADAXA and:**
 - Are over 75 years old
 - Have kidney problems
 - Have stomach or intestine bleeding that is recent or keeps coming back, or you have a stomach ulcer
 - Take other medicines that increase your risk of bleeding, including:
 - aspirin or aspirin containing products
 - long-term (chronic) use of non-steroidal anti-inflammatory drugs (NSAIDs)
 - warfarin sodium (Coumadin®, Jantoven®)
 - a medicine that contains heparin
 - clopidogrel (Plavix®)
 - prasugrel (Effient®)

Tell your doctor if you take any of these medicines. Ask your doctor or pharmacist if you are not sure if your medicine is one listed above.

- PRADAXA can increase your risk of bleeding because it lessens the ability of your blood to clot. While you take PRADAXA:
 - You may bruise more easily
 - It may take longer for any bleeding to stop

Call your doctor or get medical help right away if you have any of these signs or symptoms of bleeding:

- Unexpected bleeding or bleeding that lasts a long time, such as:
 - unusual bleeding from the gums
 - nose bleeds that happen often
 - menstrual bleeding or vaginal bleeding that is heavier than normal
- Bleeding that is severe or you cannot control
- Pink or brown urine
- Red or black stools (looks like tar)
- Bruises that happen without a known cause or get larger
- Cough up blood or blood clots
- Vomit blood or your vomit looks like "coffee grounds"
- Unexpected pain, swelling, or joint pain
- Headaches, feeling dizzy or weak

Take PRADAXA exactly as prescribed. Do not stop taking PRADAXA without first talking to the doctor who prescribes it for you. Stopping PRADAXA may increase your risk of a stroke.

PRADAXA may need to be stopped, if possible, for one or more days before any surgery, or medical or dental procedure. If you need to stop taking PRADAXA for **any reason**, talk to the doctor who prescribed PRADAXA for you to find out when you should stop taking it. Your doctor will tell you when to start taking PRADAXA again after your surgery or procedure.

See "What are the possible side effects of PRADAXA?" for more information about side effects.

What is PRADAXA?

PRADAXA is a prescription medicine used to reduce the risk of stroke and blood clots in people who have a medical condition called atrial fibrillation. With atrial fibrillation, part of the heart does not beat the way it should. This can lead to blood clots forming and increase your risk of a stroke. PRADAXA is a blood thinner medicine that lowers the chance of blood clots forming in your body.

It is not known if PRADAXA is safe and works in children.

Who should not take PRADAXA?

Do not take PRADAXA if you:

- Currently have certain types of abnormal bleeding. Talk to your doctor, before taking PRADAXA if you currently have unusual bleeding.
- Have had a serious allergic reaction to PRADAXA. Ask your doctor if you are not sure.

What should I tell my doctor before taking PRADAXA?

Before you take PRADAXA, tell your doctor if you:

- Have kidney problems
- Have ever had bleeding problems
- Have ever had stomach ulcers
- Have any other medical condition
- Are pregnant or plan to become pregnant. It is not known if PRADAXA will harm your unborn baby.
- Are breastfeeding or plan to breastfeed. It is not known if PRADAXA passes into your breast milk.

Tell all of your doctors and dentists that you are taking PRADAXA. They should talk to the doctor who prescribed PRADAXA for you, before you have **any** surgery, or medical or dental procedure.

Tell your doctor about all the medicines you take, including prescription and non-prescription medicines, vitamins, and herbal supplements. Some of your other medicines may affect the way PRADAXA works. Certain medicines may increase your risk of bleeding. See "What is the most important information I should know about PRADAXA?"

Especially tell your doctor if you take:

- rifampin (Rifater, Rifamate, Rimactane, Rifadin)

Know the medicines you take. Keep a list of them and show it to your doctor and pharmacist when you get a new medicine.

How should I take PRADAXA?

- **Take PRADAXA exactly as prescribed by your doctor.**
- Do not take PRADAXA more often than your doctor tells you to.
- You can take PRADAXA with or without food.
- Swallow PRADAXA capsules whole. Do not break, chew, or empty the pellets from the capsule.
- If you miss a dose of PRADAXA, take it as soon as you remember. If your next dose is less than 6 hours away, skip the missed dose. Do not take two doses of PRADAXA at the same time.
- Your doctor will decide how long you should take PRADAXA. **Do not stop taking PRADAXA without first talking with your doctor. Stopping PRADAXA may increase your risk of stroke.**
- Do not run out of PRADAXA. Refill your prescription before you run out. If you plan to have surgery, or a medical or a dental procedure, tell your doctor and dentist that you are taking PRADAXA. You may have to stop taking PRADAXA for a short time. See "What is the most important information I should know about PRADAXA?"
- If you take too much PRADAXA, go to the nearest hospital emergency room or call your doctor or the Poison Control Center right away.

What are the possible side effects of PRADAXA?

PRADAXA can cause serious side effects.

- See "What is the most important information I should know about PRADAXA?"
- Allergic Reactions. In some people, PRADAXA can cause symptoms of an allergic reaction, including hives, rash, and itching. Tell your doctor or get medical help right away if you get any of the following symptoms of a serious allergic reaction with PRADAXA:
 - chest pain or chest tightness
 - swelling of your face or tongue
 - trouble breathing or wheezing
 - feeling dizzy or faint

Common side effects of PRADAXA include:

- indigestion, upset stomach, or burning
- stomach pain

Tell your doctor if you have any side effect that bothers you or that does not go away.

These are not all of the possible side effects of PRADAXA. For more information, ask your doctor or pharmacist.

Call your doctor for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088.

How should I store PRADAXA?

- Store PRADAXA at room temperature between 59°F to 86°F (15°C to 30°C). After opening the bottle, use PRADAXA within 30 days. Safely throw away any unused PRADAXA after 30 days.
- Store PRADAXA in the original package to keep it dry. Keep the bottle tightly closed.

Keep PRADAXA and all medicines out of the reach of children.

General information about PRADAXA

Medicines are sometimes prescribed for purposes other than those listed in a Medication Guide. Do not use PRADAXA for a condition for which it was not prescribed. Do not give your PRADAXA to other people, even if they have the same symptoms. It may harm them.

This Medication Guide summarizes the most important information about PRADAXA. If you would like more information, talk with your doctor. You can ask your pharmacist or doctor for information about PRADAXA that is written for health professionals.

For more information, go to www.PRADAXA.com or call 1-800-542-6257 or (TTY) 1-800-459-9906.

What are the ingredients in PRADAXA?

Active ingredient: dabigatran etexilate mesylate

Inactive ingredients: acacia, dimethicone, hypromellose, hydroxypropyl cellulose, talc, and tartaric acid. The capsule shell is composed of carrageenan, FD&C Blue No. 2, FD&C Yellow No. 6, hypromellose, potassium chloride, titanium dioxide, and black edible ink.

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• EXPLORATION



Cady Coleman poses with her new space station crewmate: the first orbital android. Five cameras, one infrared, are mounted in the helmet.

Go Up, Young Bot

Androids and spacecraft have been science-fiction staples for decades, but for the first time that pairing

is being tested in orbit. The pioneering Robonaut 2 (aka R2) is aboard the International Space Station, preparing to go to work—and to validate the idea that a humanoid robot can be an asset to a busy crew. NASA and General Motors engineers designed the legless R2 to perform routine tasks—such as flipping switches, taking simple measurements and polishing handrails—so scientists have more time for substantive work. “If Robonaut can provide just an hour’s worth of relief to the crew, that would make the experiment worth it,” says deputy project manager Nic Radford. —STEVE ROUSSEAU

Now

Getting Acclimated

Before R2 gets to work, NASA engineers calibrate its movements for a zero-g environment. “Now that you don’t have gravity, there is no weight on the arm,” Radford explains. “The robot moves with less effort.” The adjustments ensure, for example, that the \$2.5 million R2 won’t punch a hole through an instrument panel while simply trying to push a button.

Soon

Learning on the Job

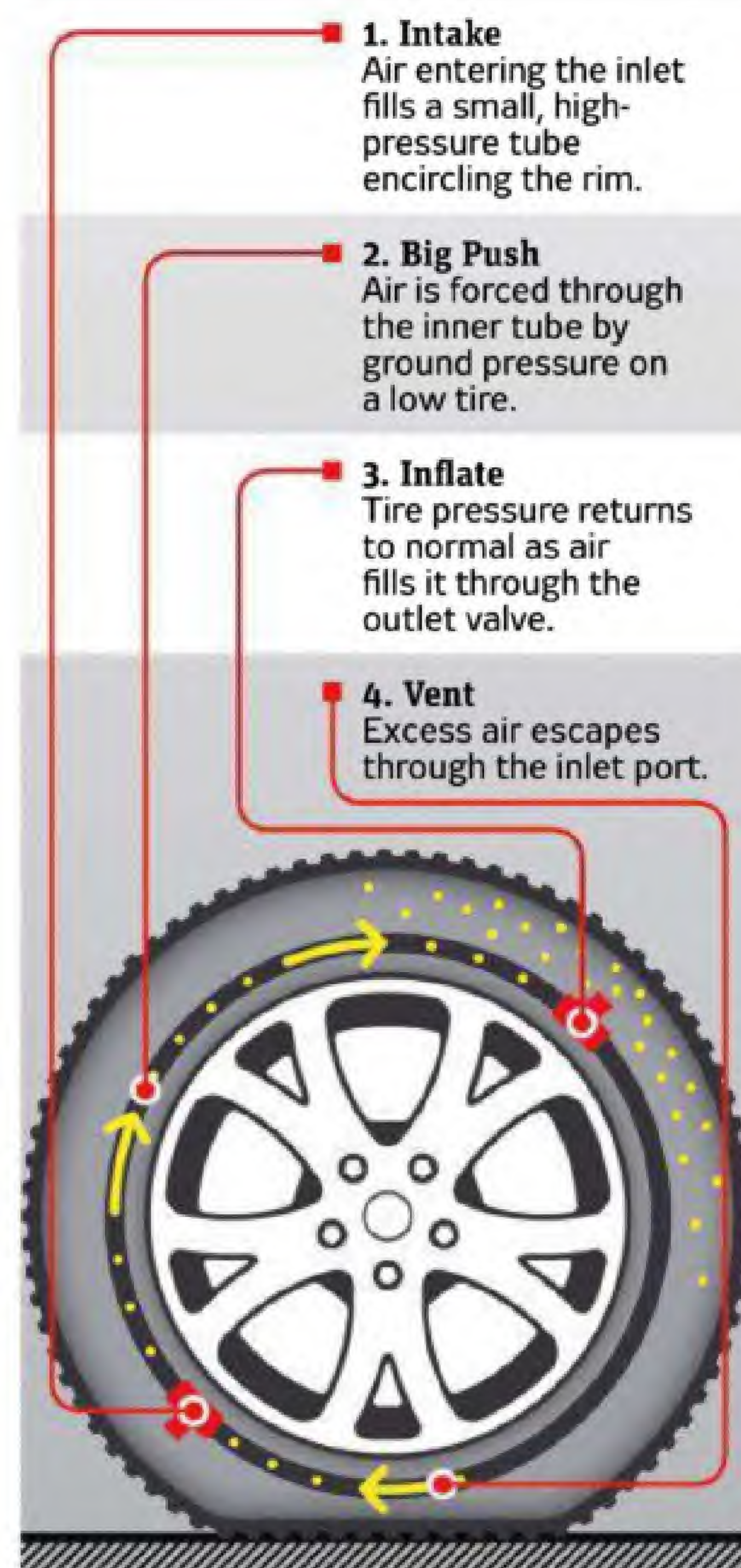
R2 will be given a task by engineers, then decide for itself how to complete it. “It’s not an artificially intelligent robot, but it has the ability to do a task in an intelligent way,” Radford says. Using visual processors and more than 350 force and torque sensors, R2 will be able to detect if it has correctly responded to a command, such as flipping a switch or tightening a bolt.

Future

Stretching Its Legs

On Earth, R2 weighs 330 pounds, so it’s not a good idea to have it floating around a space station. NASA plans to send the lower limbs to the ISS to enable the robot to grasp handrails and swing like a monkey moving through trees. Robonaut 2 will also be able to dodge obstacles. “It’ll say, Hey, something just floated by—I need to not run into it,” Radford says.

• FUTURE RIDES



The Self-Inflating Tire

➔ **Searching for the air hose** in the grimmest corner of a neighborhood service station may soon become a thing of the past. With the help of a \$1.5 million Department of Energy grant, Goodyear is developing a tire that regulates its own air pressure. Though the company refused to leak details of how the system works, a 2009 patent application shows that the tire employs a pressurized internal tube with inlet and outlet valves. This differs from the automatic inflation system on military vehicles that use onboard compressors. “The Air Maintenance Technology system is powered by the tire itself as it rolls down the road,” says Goodyear chief technical officer Jean-Claude Kihn. Underinflation can lead to tire failure and a possible crash, but in most cases it just wastes fuel. According to Goodyear, underinflation cuts a car’s efficiency by 2.5 to 3.3 percent, which, at current fuel prices, effectively adds more than 10 cents per gallon. —DAN CARNEY

PREHISTORY MYSTERY

Researcher Craig Feibel uses the magnetic history of West Turkana, Kenya, to determine the date early man crafted stone hand axes.



Tool Time

→ Lab experiments have shed light on an enduring question about humanity's relationship with tools. Measurements at Lamont-Doherty Earth Observatory's Paleomagnetism Lab outside New York City show that our ancestors had an impressive tool chest at least 1.76 million years ago, 300,000 years earlier than previously thought. The researchers were able to determine the date of sophisticated hand axes and other cutting tools found in Kenya by examining surrounding mudstone that preserved the direction of Earth's magnetic field. Because this field shifts periodically, paleontologists can analyze this record to fix the age of the sediments from which the tools were quarried. It proves that *Homo erectus*, a precursor to modern humans that died out 70,000 years ago, used axes with chiseled edges to butcher and maybe hunt large animals like elephants. —ALEX HUTCHINSON



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IN WRANGLER RELAXED FIT

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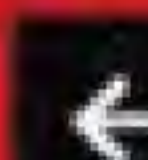


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THE GUY WHO THINKS HE HAS EVERYTHING IS WRONG. WE ID SEVEN TYPES OF POPMECH MEN AND PICK CAN'T-MISS GIFTS. *BY HARRY SAWYERS*

At POPULAR MECHANICS we're proud to serve a diverse readership. Basement inventors, compulsive renovators, gadget gurus, bicycling fanatics, backwoods trailblazers, greasy-palmed gearheads—we cherish every last one of you. But you guys can be hard to please. Lest you end up empty-handed this holiday season, we highlight items tailored for each of the many PM personalities. Use our guide to simplify shopping or drop a hint on your gift giver. Merry, merry!

PHOTOGRAPH BY **THOMAS PRIOR**

POPULARMECHANICS.COM | DECEMBER 2011 **29**

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PAGE 36



1
WIN THIS!
PAGE 36



BASEMENT INVENTOR

1 Perform rapid prototyping at home with the **MakerBot Thing-O-Matic (\$1300)**, a 3D printer that turns a digital blueprint into a tangible object. Load up a resin spool, import a SketchUp or CAD file, and watch anything from a mallet to 3D text reading "Happy Holidays" appear in the 12 x 12 x 16-inch cube. Paint, sand, machine or melt the creations—see thingiverse.com for sky's-the-limit ideas.

2 Brewers, bakers, candlestick makers and budding chemical

engineers all need a scale like the digital **Escali Alimento 136 (\$90)**, which is

accurate to 0.1 grams, up to 15 pounds. A perfect batch of rocket fuel, finally!

3 It shows live AC and DC current, sure, but a **Fluke 233 Multimeter (\$300)** has a detachable display as well. Put the leads on two wires, take its face to the power source and detect the purpose of a mystery switch.

4 Compact and clear, General's **527 Eye Loupe (\$8)** has shown objects at 5x size for over 50 years.

5 Dremel's new **3000 Rotary Tool (\$70)** advances the popular 300 line with a shorter body, a wrench-free bit grip and better ventilation.

6 Learn the basics of AI from a pioneer in the field with the fourth edition of Gordon McComb's **Robot Builder's Bonanza (\$30)**, a book of over 100 home projects. The update has more illustrations, ideas for new bot-control devices and classic builds.

The 35-year overnight sensation. Back in 1976, we really didn't know how big the Honda Accord would become. We just knew we'd put all our best thinking into it. Drivers loved how fun and smart it was. It was fuel-efficient and low-hassle. It was refreshingly different. And every year since, we've made it better. From lessons learned making race cars, motorcycles, and even jet planes, the Accord is the sum of our best and latest thinking. And for two years running, J.D. Power and Associates has named the Honda Accord "Highest Ranked Midsize Car in Initial Quality." Thirty-five years later, it's still the one.

The one. The 34 mpg hwy* Accord.



accord.honda.com 1-800-33-Honda †Honda Accord received the lowest number of problems per 100 vehicles among midsize cars in the proprietary J.D. Power and Associates 2011 Initial Quality Study.™ Study based on responses from 73,790 new-vehicle owners, measuring 234 models and measures opinions after 90 days of ownership. Proprietary study results are based on experiences and perceptions of owners surveyed in February – May 2011. Your experiences may vary. Visit jdpower.com. *23 city/34 hwy/27 combined 2012 EPA mileage estimates for Accord 4-cylinder Sedan models. Use for comparison purposes only. Actual mileage will vary. ©2011 American Honda Motor Co., Inc.

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PAGE 36

MASTER MECHANIC



STOCKING
STUFFER

2

Set an old drill press in motion with a **Master Chuck Key (\$25)**, Graham Tool's magnet-backed chuck-jaw setter.

WIN THIS!

PAGE 36



3

Fix it at home or know what to tell a pro—Actron's **CP9580 AutoScanner (\$252)** diagnoses a newer car's ills.

4

Auto-darkening welding helmets like Lincoln's **Viking 3350 (\$272)** make it even easier to lay a stack of dimes. The 3.5-inch-square screen offers a fine view, and the sensitivity and speed settings adjust infinitely. Design options include flags, flames and lots of chrome.



5

Made of a flawless steel M16 ammo can, Graham Tool's **First Aid Kit (\$75)** has enough Johnson & Johnson gauze and bandage gear to treat a minor shop mishap with a proper field dressing.



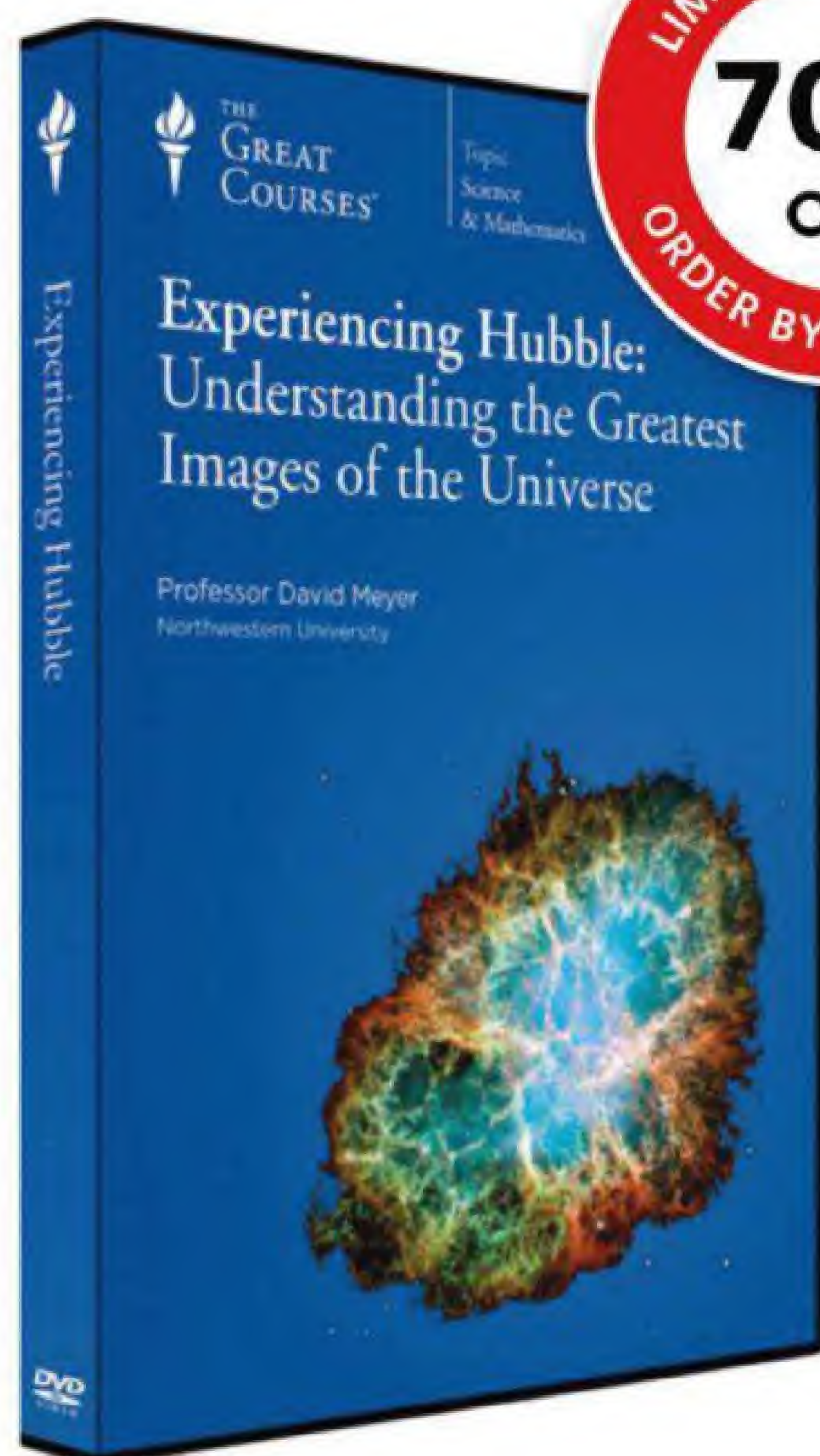
Universal teeth and pass-through backs in Craftsman's **Max Access 19-Piece Socket Set (\$45)** crank almost any type of nut or bolt.

1





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1

STOCKING
STUFFER

2



3



4

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PAGE 36



5

6

SPOKES PERSON

1
Carry Topeak's **Road Morph G (\$45)** to pump up limp tubes that use Schrader or Presta valves.

2
Far more effective than a holler, the **Crane Bell (\$12)** uses a sharp lever

strike to ding pedestrians back onto the sidewalk.

3
Be bright and ride at night with Planet Bike's 2-watt **Blaze LED Headlight (\$60)**. It's good for 15 hours' run time on two AA batteries.

4
With a look somewhere between a bike lane and a half-pipe, the **Uvex Urban Helmet (\$65)** makes protection stylish. Straps on the chin and headband adjust to make the 250 grams

seem to vanish. Wear it. Leave the earbuds in a saddlebag.

5
Mounted to studs, Knife & Saw's top-tier walnut **Bike Shelf (\$300)** displays a two-wheeler like a work of art.

6
The classic single-speed **Raleigh One Way (\$750)** has the elegance of a fixed-gear bike, but it trades the pretension for practicality. Fenders and a chain guard protect a commuter's work clothes from mud and grease. A weathered Brooks saddle comes standard to match the timeless leather grip tape. Sure, the cycle is steel, but with high-tech flourishes. Work the Suntour crank, jam the Tektro brakes and it'll be clear—the One Way pairs retro style with a fine modern ride.

The Next Generation.

2 BRIGHT LED LIGHTS
UP TO 180 LUMENS

UP TO 270°
ADJUSTABLE
HINGE

INNOVATIVE
BUNGEE
HOOKING
MECHANISM

3 INTEGRATED MAGNETS



2 HIGH POWERED LED'S
40x
BRIGHTER
THAN TYPICAL LED'S

The Might-D-Light™ Mini folding LED worklight is the next generation in portable, hands-free lighting. Whether it is home maintenance, auto repair or outdoor recreation, the Mini's versatile, compact design is perfect for illuminating those hard to reach places.

DORM- ROOM MEDIA BARON



1

The **Toshiba R835 (\$750)** is a well-specced workhorse in a magnesium shell.



STOCKING
STUFFER

2

One-minute espresso in the **AeroPress (\$25)** makes a mockery of the dining-hall percolator.



3

Two terabytes in the **iomega eGo (\$160)** hold the biggest media collection in the freshman class.



4

The tiny **Roku 2 (\$99)** puts Netflix, Hulu, Pandora and Angry Birds on TV with a game-friendly remote.

WIN THIS!
SEE BELOW



5

Don't let a dead battery ruin a day on the quad—use the **Joos Solar Charger (\$140)** to soak up and store wattage.



6

Loud enough to wake the RA but small enough to perch on a desk, the unassuming **Audyssey Lower East Side Speakers (\$250)** produce cleaner sound than your typical 5.1-channel box-o'-speakers. Carefully tuned audio processing—not to mention the generous woofers and silk-dome tweeters—keeps the lows low, the highs high, and the midrange, well, just right.



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RANDOM DRAW SWEEPSTAKES: No purchase necessary to enter or win. Popular Mechanics 2011 Wish List Sweepstakes. Sponsored by Hearst Communications, Inc. Beginning November 7, 2011, at 12:01 AM (ET) through December 15, 2011, at 11:59 PM (ET) go to popularmechanics.com/wishlist2011 and complete and submit the entry form pursuant to the online instructions. Odds of winning will depend upon the total number of eligible entries received. Must be a legal resident of the 50 United States, District of Columbia or Canada who has reached the age of majority in his or her state, territory, or province of residence at time of entry. Void in Puerto Rico, in the Province of Quebec and where prohibited by law. Sweepstakes subject to complete official rules available at popularmechanics.com/wishlist2011.

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HIGH-TECH HIGH ROLLER



1

Smile if you like big sensors. The **Sony Nex-C3 (\$599)** camera packs SLR quality in a tiny package.

WIN THIS!

PAGE 36



2

The **Dyson Hot Fan Heater (\$399)** turns chilly into toasty, with style points to spare.

3

Norelco's new king of electric razors, the **1290X SensoTouch 3D (\$280)**, vanquishes stubborn stubble to leave skin royally smooth.



4

Share a speedy cellular cloud with up to five Wi-Fi-enabled devices on the **Verizon 4G LTE MiFi Hotspot (\$30 on two-year contract)**. Link in the crowd at a cafe or keep the kids from drifting off in search of a stronger signal.



STOCKING
STUFFER

5

Mankind will probably forget how to change a light bulb before the **Pixi A19 LED Bulb (\$18)** burns out. Rated for 50,000 hours (that's more than 5.5 years of constant use), this modern marvel brings the best idea Edison ever had into the digital age. Adopt it early at half off a typical LED's price tag.



6

Spoil a gadget with the rich leather of the **Fossil Estate (\$75)**, a swanky sleeve to keep the iPad cushy.

IS NATURE CALLING AND CALLING?



Jalyn®

(dutasteride and tamsulosin HCl)
Capsules
0.5 mg/0.4 mg

Going Frequently • Incomplete Emptying • Waking Up to Go • Flow Starts and Stops • Trouble Going

For guys with symptomatic benign prostatic hyperplasia (BPH), nature calls a little too often. JALYN can help reduce urinary symptoms of BPH in men with an enlarged prostate. JALYN is not approved for the prevention of prostate cancer.

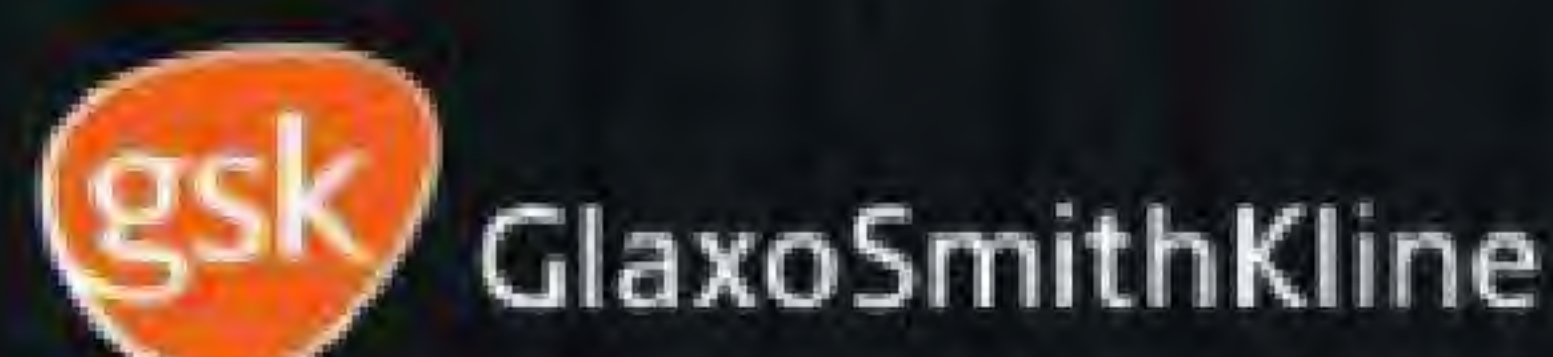
It's time to ask your doctor if JALYN is right for you.

www.JALYN.com

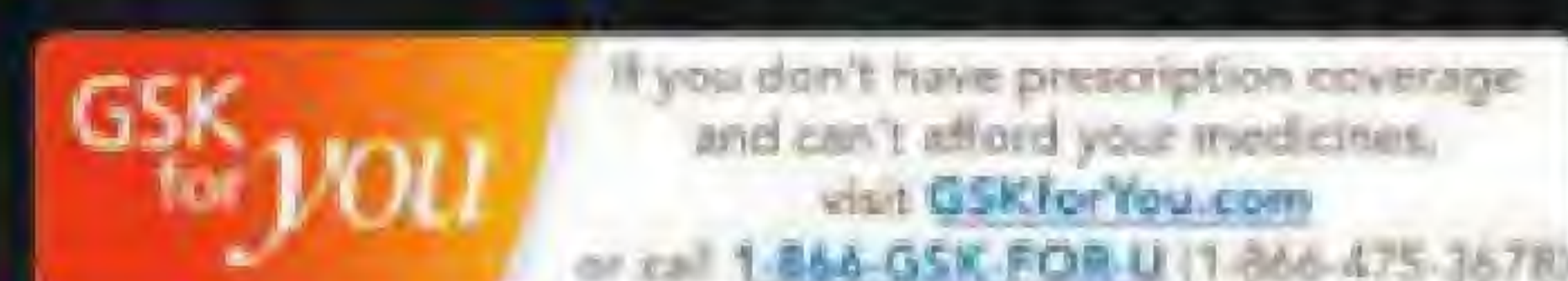
Important Safety Information About JALYN

- JALYN is for adult men only. Women should not take or touch JALYN due to risk of a specific birth defect. If a woman comes in contact with leaking JALYN Capsules, she should wash the contact area immediately with soap and water.
- Do not take JALYN if you are allergic to dutasteride, finasteride, tamsulosin, or any of the ingredients in JALYN.
- JALYN may cause rare and serious allergic reactions, including: swelling of your face, tongue, or throat, and serious skin reactions, such as skin peeling. Get medical help right away if you have these serious allergic reactions.
- JALYN may cause a sudden drop in blood pressure upon standing, especially when starting treatment, which may cause you to faint, or feel dizzy or lightheaded. Avoid driving or operating hazardous equipment when starting or restarting JALYN.
- Tell your doctor about all the medicines you take, including prescription and non-prescription medicines, vitamins, and herbal supplements. JALYN and other medicines may affect each other, causing side effects.
- Some types of medicines should not be taken with JALYN, including: ketoconazole, an antifungal medication, which if taken with JALYN can increase levels of tamsulosin, a component of JALYN; and alpha-blockers, like tamsulosin, which if taken with JALYN may cause fainting, dizziness, or feeling lightheaded.
- Some types of medicines should be used with caution when taken with JALYN, including: erythromycin, paroxetine, or terbinafine, which when taken with JALYN can increase levels of tamsulosin, a component of JALYN; cimetidine; certain types of medicines that are commonly used to treat erectile dysfunction, which when taken with JALYN may cause fainting, dizziness, or feeling lightheaded; and warfarin.
- Only your healthcare provider can tell if your symptoms are due to BPH or a more serious condition like prostate cancer. See your doctor for regular exams.
- JALYN may cause serious side effects including a higher chance of a more serious form of prostate cancer.
- Your healthcare provider may check you for other prostate problems, including prostate cancer, before you start and while you take JALYN. A blood test called PSA (prostate-specific antigen) is sometimes used to see if you might have prostate cancer. JALYN will reduce the amount of PSA measured in your blood. Your healthcare provider is aware of this effect and can still use PSA to see if you might have prostate cancer. Increases in your PSA levels while on treatment with JALYN (even if the PSA levels are in the normal range) should be evaluated by your healthcare provider.
- Rarely, JALYN can cause a painful erection. If this happens get medical help right away.
- Do not donate blood until 6 months after stopping JALYN.
- Before you take JALYN, tell your doctor if you: have a history of low blood pressure, plan to have cataract surgery, are allergic to sulfa medications, take medicines to treat high blood pressure, have liver problems, or have any other medical conditions.
- The most common side effects include: ejaculation problems, trouble getting or keeping an erection (impotence), a decrease in sex drive (libido), decreased amount of semen released during sex, dizziness, enlarged or painful breasts (if you notice breast lumps or nipple discharge, you should talk to your healthcare provider), and runny nose.

Please see the next page for Patient Information about JALYN.



You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.



PATIENT INFORMATION
JALYN™ [JAY-LIN]
(dutasteride and tamsulosin hydrochloride)
Capsules

JALYN is for use by men only.

Read this patient information before you start taking JALYN and each time you get a refill. There may be new information. This information does not take the place of talking with your healthcare provider about your medical condition or your treatment.

What is JALYN?

JALYN is a prescription medicine that contains 2 medicines: dutasteride and tamsulosin. JALYN is used to treat the symptoms of benign prostatic hyperplasia (BPH) in men with an enlarged prostate.

Who should not take JALYN?

Do Not Take JALYN if you are:

- pregnant or could become pregnant. JALYN may harm your unborn baby. Pregnant women should not touch JALYN Capsules. If a woman who is pregnant with a male baby gets enough JALYN in her body by swallowing or touching JALYN, the male baby may be born with sex organs that are not normal. If a pregnant woman or woman of childbearing potential comes in contact with leaking JALYN Capsules, the contact area should be washed immediately with soap and water.
- a child or teenager.
- allergic to dutasteride, tamsulosin, or any of the ingredients in JALYN. See the end of this page for a complete list of ingredients in JALYN.
- taking another medicine that contains an alpha-blocker.
- allergic to other 5 alpha-reductase inhibitors, for example, PROSCAR® (finasteride) Tablets.

What should I tell my healthcare provider before taking JALYN?

Before you take JALYN, tell your healthcare provider if you:

- have a history of low blood pressure
- take medicines to treat high blood pressure
- plan to have cataract surgery
- have liver problems
- are allergic to sulfa medications
- have any other medical conditions

Tell your healthcare provider about all the medicines you take, including prescription and non-prescription medicines, vitamins, and herbal supplements. JALYN and other medicines may affect each other, causing side effects. JALYN may affect the way other medicines work, and other medicines may affect how JALYN works.

Know the medicines you take. Keep a list of them to show your healthcare provider and pharmacist when you get a new medicine.

How should I take JALYN?

- Take JALYN exactly as your healthcare provider tells you to take it.
- Swallow JALYN Capsules whole. Do not crush, chew, or open JALYN Capsules because the contents of the capsule may irritate your lips, mouth, or throat.
- Take your JALYN 1 time each day, about 30 minutes after the same meal every day. For example, you may take JALYN 30 minutes after dinner every day.
- If you miss a dose, you can take it later that same day, 30 minutes after a meal. Do not take 2 JALYN Capsules in the same day. If you stop or forget to take JALYN for several days, talk with your healthcare provider before starting again.
- If you take too much JALYN, call your healthcare provider or go to the nearest hospital emergency room right away.

What should I avoid while taking JALYN?

- Avoid driving, operating machinery, or other dangerous activities when starting treatment with JALYN until you know how JALYN affects you. JALYN can cause a sudden drop in your blood pressure, especially at the start of treatment. A sudden drop in blood pressure may cause you to faint, feel dizzy or lightheaded.
- You should not donate blood while taking JALYN or for 6 months after you have stopped JALYN. This is important to prevent pregnant women from receiving JALYN through blood transfusions.

What are the possible side effects of JALYN?

JALYN may cause serious side effects, including:

- **Decreased blood pressure.** JALYN may cause a sudden drop in your blood pressure upon standing from a sitting or lying position, especially at the start of treatment. Symptoms of low blood pressure may include:
 - fainting
 - dizziness
 - feeling lightheaded
- **Rare and serious allergic reactions, including:**
 - swelling of your face, tongue, or throat
 - serious skin reactions, such as skin peelingGet medical help right away if you have these serious allergic reactions.
- **Higher chance of a more serious form of prostate cancer.**
- **Eye problems during cataract surgery.** During cataract surgery, a condition called intraoperative floppy iris syndrome (IFIS) can happen if you take or have taken JALYN in the past. If you need to have cataract surgery, tell your surgeon if you take or have taken JALYN.
- **A painful erection that will not go away.** Rarely, JALYN can cause a painful erection (priapism), which cannot be relieved by having sex. If this happens,

get medical help right away. If priapism is not treated, there could be lasting damage to your penis, including not being able to have an erection.

The most common side effects of JALYN include:

- ejaculation problems
- trouble getting or keeping an erection (impotence)
- a decrease in sex drive (libido)
- dizziness
- enlarged or painful breasts. If you notice breast lumps or nipple discharge, you should talk to your healthcare provider.
- runny nose

Dutasteride, an ingredient of JALYN, has been shown to reduce sperm count, semen volume, and sperm movement. However, the effect of JALYN on male fertility is not known.

Prostate-Specific Antigen (PSA) Test: Your healthcare provider may check you for other prostate problems, including prostate cancer, before you start and while you take JALYN. A blood test called PSA (prostate-specific antigen) is sometimes used to see if you might have prostate cancer. JALYN will reduce the amount of PSA measured in your blood. Your healthcare provider is aware of this effect and can still use PSA to see if you might have prostate cancer. Increases in your PSA levels while on treatment with JALYN (even if the PSA levels are in the normal range) should be evaluated by your healthcare provider.

Tell your healthcare provider if you have any side effect that bothers you or that does not go away.

These are not all the possible side effects with JALYN. For more information, ask your healthcare provider or pharmacist.

Call your doctor for medical advice about side effects. You may report side effects to the FDA at 1-800-FDA-1088.

How should I store JALYN?

- Store JALYN Capsules at room temperature (59° to 86°F or 15° to 30°C).
- JALYN Capsules may become deformed and/or discolored if kept at high temperatures.
- Do not use or touch JALYN if your capsules are deformed, discolored, or leaking.
- Safely throw away medicine that is no longer needed.

Keep JALYN and all medicines out of the reach of children.

Medicines are sometimes prescribed for purposes other than those listed in a patient page. Do not use JALYN for a condition for which it was not prescribed. Do not give JALYN to other people, even if they have the same symptoms that you have. It may harm them.

This patient information page summarizes the most important information about JALYN. If you would like more information, talk with your healthcare provider. You can ask your pharmacist or healthcare provider for information about JALYN that is written for health professionals.

For more information, go to www.JALYN.com or call 1-888-825-5249.

What are the ingredients in JALYN?

Active ingredients: dutasteride and tamsulosin hydrochloride

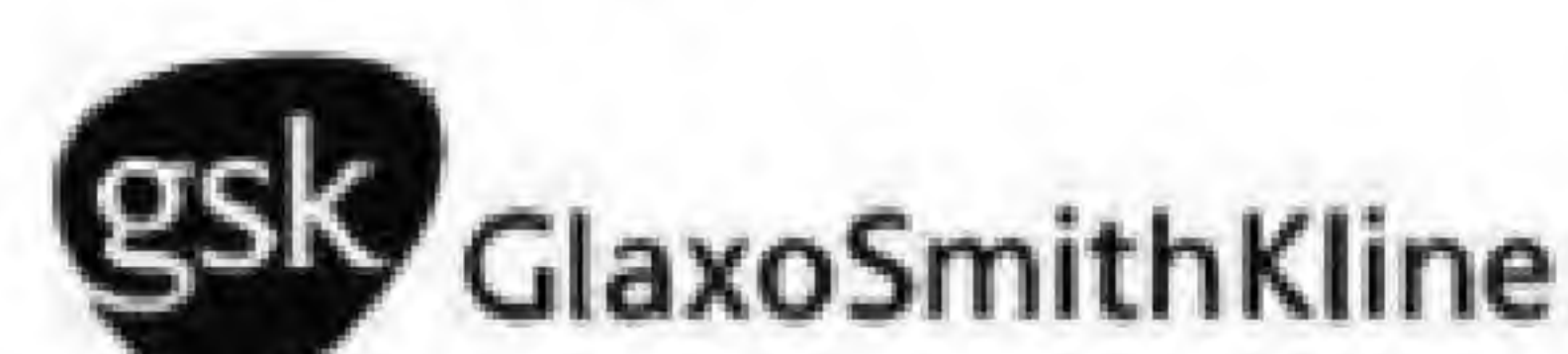
Inactive ingredients: black ink, butylated hydroxytoluene, carrageenan, FD&C yellow 6, ferric oxide (yellow), gelatin (from certified BSE-free bovine sources), glycerin, hypromellose, iron oxide red, methacrylic acid copolymer dispersion, microcrystalline cellulose, mono-di-glycerides of caprylic/capric acid, potassium chloride, talc, titanium dioxide, and triethyl citrate.

How does JALYN work?

JALYN contains 2 medications, dutasteride and tamsulosin. These 2 medications work in different ways to improve symptoms of BPH. Dutasteride shrinks the enlarged prostate and tamsulosin relaxes muscles in the prostate and neck of the bladder. These 2 medications, when used together, can improve symptoms of BPH better than either medication when used alone.

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D-73614 Schorndorf, Germany
and
Rottendorf Pharma GmbH
D-59320 Ennigerloh, Germany

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June 2011

JLN:2PIL

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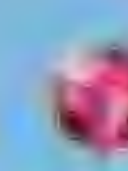










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The symbol of infinity—what a beautiful way to express a love that truly is forever! Now comes a unique jewelry exclusive created just for the two of you—the “Love Never Ends” Personalized Diamond and Birthstone Pendant available only from The Bradford Exchange.

Exquisitely designed, the “Love Never Ends Personalized Diamond & Birthstone Pendant” is finely hand-crafted of solid sterling silver. Fashioned in the graceful shape of the symbol for infinity, the pendant sparkles with a genuine solitaire diamond and is personalized with the two engraved names of your choice. Two heart charms are beautifully suspended from the symbol—each one adorned with a genuine birthstone that you also choose, and the matching 18” rope chain of solid sterling silver completes the look.

The perfect gift of love, the “Love Never Ends Personalized Diamond & Birthstone Pendant” is a superb value at \$119, payable in 4 easy monthly installments of \$29.75 and backed by our 120-day guarantee. But hurry, this is a limited time offer. To reserve, send no money now; just mail the Reservation Application today!

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Names are limited to 10 letters each)

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2. <input type="text"/>	<input type="text"/>

Signature

Mrs. Mr. Ms. Name (Please Print Clearly)

Address

City State Zip

01-07928-001-E27591



WIN THIS!

PAGE 36

1



2



3



4



5



6



7

STOCKING
STUFFER

COMPULSIVE RENOVATOR

1

With a metal clutch, a four-pole motor and 50 percent more run time than its predecessor, the Bosch 18-volt **Gen 2 Brute (\$288)** takes tool tech to the limit.

2

DeWalt's **5-in-1 Hack saw (\$22)** is a versatile

close-quarters emergency cutter.

3

Milwaukee's third **M-Spector (\$200)**, a snaking camera with a lighted tip, is half the size of its old 17-mm diameter. Now it fits an 11-mm spark plug hole. The memory is better and the price is lower, too.

4

Too much time has passed since a nice ratcheting screwdriver made the toolbox roster, but Channellock's **13 'N 1 Screwdriver (\$34)** ends the drought with dual-ended bits clipped in the butt and a smooth 28-tooth ratchet.

5

Stud out closets or stick-frame an addition with Paslode's new **Cordless Framing Nailer (\$399)**. A slim lithium-ion battery

runs a CPU, acts as an air-injecting carburetor and manages fuel-cell ignition timing.

6

Find insulation gaps or measure a grill's heat with the Porter-Cable **18v Infrared Thermometer (\$60)**. Temperature changes alter its IR beam color.

7

Keep tile, art or cabinetry perfectly in line with Black & Decker's **SureGrip Laser Level (\$28)**. A spirit vial aligns the beam. The tool can emit a tone when a level setting is hit—helpful when stooped beneath a stove to adjust the legs' height.

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BOSE
Better sound through research

TRAIL BLAZER



WIN THIS!

PAGE 36

2

A plucky spring snaps open the serrated 4-inch blade on Gerber's **Answer F.A.S.T.** (\$85) pocketknife.

3

Enough gear for a full-day trek or an overnight hike fits nicely in Gregory's midsize **Savant 48** (\$179), a bag with an aluminum and composite internal frame and a rotating waist.



1

The **MSR Reactor Stove** (\$160) boils a liter of water in 3 minutes on a radiant burner and wind-shielded heat exchanger.

4

Designers scanned more than 20,000 folks' feet to build the molds used for the **TrekSta Men's Evolution Mid GTX** (\$140), a 14-ounce boot contoured to precisely fit a foot. A waterproof Gore-Tex layer and slip-resistant polymer patches on the boot's sole provide a sure step on a winter hiking trail or ice-capped sidewalk.



5

Signal for help or indicate all is well with a satellite-based **Spot 2 GPS Messenger** (\$170).



6

A flame-free element heats extremities for 12 hours with the **Zippo Hand Warmer** (\$20).




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VERSATILITY

FUN
TO DRIVEOFF-ROAD
ABILITY

LUXURY

PERFORMANCE

DESIGN

VALUE

FUEL
EFFICIENCY

WORKHORSE

TECHNICAL
INNOVATIONPOPULAR MECHANICS
TOP 10 CARS

New Cars

2012

**AUTOMOTIVE
EXCELLENCE
AWARDS**

● **The automotive industry's** gas pedal is still floored. New-vehicle sales are some 10 percent above last year's and nearly 25 percent higher than the year everyone in the business wants to forget—2009. But since sales are still lower than the boom days of the early noughts, carmakers are fighting for slices of a smaller pie. And so, the bombs have been dropped from the lineups. New models are increasingly polished, capable and aggressively priced. Consequently, picking the best comes down to sussing out which car best nailed the details. Finding the brightest is an enviable task for sure, but not an easy one. After comprehensive test drives of all the new models, we noted the good, the bad, and, yes, the ugly. Then the PM test crew debated each car's functionality, technology, style, performance, value, and, critically, what it's like to drive. The winners are the true overachievers in their segments. These are the 10 best cars and trucks for 2012.

● by the **PM Auto Team**

● **VERSATILITY**

2012
**DODGE
DURANGO**

Base Price: **\$28,995**

The promise of the modern SUV is having a vehicle that can take you—and your gear and family—anywhere.

It's not every day that you pack in all the kids, hitch up a camper trailer and trundle down a gnarly trail to a secluded spot, but it's nice to know you've got the option. The Durango is a vehicle that provides nearly limitless opportunities. It seats seven in a cleanly designed interior, can tow up to 7400 pounds and has the mechanical hardware—a robust center differential rather than a light-duty clutch pack—to traverse terrain that would humble most sport utes. During a recent seven-SUV torture test on a Michigan sand dune, we used the Durango to tow out the other SUVs that got beached ("Where the Pavement Ends," August).

But the Durango is not simply a talented

off-roader. There's no on-road penalty for its capabilities. It drives with a sharpness that belies its 2½ tons and its commodious interior. On the highway, drivers can luxuriate in the rich materials, throne-like seats and an abundance of available features, including a 360-hp V8 and adaptive cruise control. If you skip that V8, which is a wise move considering how well the 290-hp V6 performs, the Durango returns decent fuel economy. We averaged 20 mpg during our test. Plus the Durango is wrapped in a clean and attractive body. This is one vehicle that really can do it all.



VERSATILITY

FUN
TO DRIVEOFF-ROAD
ABILITY

LUXURY

PERFORMANCE

DESIGN

VALUE

FUEL
EFFICIENCY

WORKHORSE

TECHNICAL
INNOVATION

• FUN TO DRIVE

2012
BMW 1M
COUPE

Base Price: \$47,010

Sometimes personality trumps style—just ask us about the BMW 1M. It's the least expensive of BMW's mighty high-po M cars and also the least pretty. The flared fenders and gaping mouth tacked onto the base 1 Series make it even chunkier, not sleek and lithe like a typical sports car. But we still clutch the keys like a toddler with a lollipop. There's a surplus of performance—a turbocharged 335-hp straight-six engine, mammoth tires and brakes, and stiffer suspension—but speed is not the main thrill. The other subjective measures, such as perfectly linear brake action, steering that feels hard-wired to your brain, delicate road signals communicated through the seat, and the creamy six-speed manual transmission, all combine for a dynamic delight. And it's those

traits that separate simply fast cars from the truly rewarding ones. The 1M is simultaneously ferocious and controllable, a machine that doesn't neuter the driver with safe but boring handling. It nudges you to explore that outer edge of speed and control, and then brings you safely back. After a day or so behind the wheel, it's all too easy to believe the fantasy that you're fit for the Monaco Grand Prix. The 1M is not a car that simply gets you from place to place; instead it seduces you into taking the long route to your destination just so you can exercise its talents a little longer.

5
ROADS
MADE
FOR
THE 1M

1. **CALIFORNIA**
Go north from Ojai, and slice through the desolate Los Padres as **ROUTE 33** doubles back on itself

several times. After 37 miles, head east on Lockwood Valley Road for another mind-blowing 25 miles until reaching I-5.

2. **MONTANA**
Start in Broadus and ride epic **U.S. HIGHWAY 212**—the Beartooth Highway—all the way into Yellowstone. Find out why it's known as the most beautiful drive in America.

3. **COLORADO**
With no major junctions along its 120-mile length, its smooth blacktop, and enough elevation rise to incite altitude sickness, **HIGHWAY 149** is a diamond among Colorado's deep reserves of stellar driving roads.

4. **TENNESSEE**
Known as the Tail of the Dragon, **ROUTE 129** packs 318 curves in an

11-mile stretch. Combine the Tail with routes 143, 165 and 360 for 120 miles of driving nirvana. Avoid on major holidays.

5. **VERMONT**
ROUTE 100 is a picturesque north-south byway that runs for more than 200 miles, from Massachusetts nearly to Canada. Hit it in the warm months to experience the full vibrancy of the Green Mountains.

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VERSATILITY

FUN
TO DRIVEOFF-ROAD
ABILITY

LIVABLE

THE
WRANGLER'S
ALL-TERRAIN
ANATOMY**ENGINE**

- The new 3.6-liter V6 produces 285 hp, 83 more than last year's, yet is 21 percent more fuel-efficient. An aluminum block saves 90 pounds over the old iron 3.8-liter.

TRANSMISSION

- The five-speed automatic has a wider ratio spread for better fuel economy. The six-speed manual is still available.

FRONT AXLE

- No independent suspension here. The rigid axle is tough and can be optioned with an antiroll bar that electronically disengages so the axle can freely rock and follow rough terrain.

TRANSFER CASE

- Once engaged, the transfer case sends power to the front wheels. Rubicon models offer a ridiculously low 4.10:1 low-range ratio so they can inch along slower than a walking pace and gingerly crawl over obstacles.

REAR AXLE

- Drivers can outfit the Wrangler with one of three final-drive ratios to enhance either fuel economy or low-speed crawling ability.

OFF-ROAD ABILITY2012
JEEP WRANGLER

Base Price: \$22,045

The constant struggle for Jeep is civilizing the Wrangler without killing its off-road prowess. After all, no matter how capable it may be on the Rubicon Trail, a scant few customers are willing to endure a choppy on-road ride or an interior racket that sounds like a snare drum in an oilcan. In the past 18 months, the Wrangler has nearly been upended. The designers ditched the granite-hard interior for one with softer materials and gentler curves. They redesigned and thickened the soft top to reduce wind noise. A more powerful and efficient driveline replaced the ancient 3.8-liter V6 and four-speed automatic. The new Wrangler, which is available with two or four doors, is the most livable ever. And it still has the steep approach and departure angles, stout running gear and hardware—skidplates and locking differentials—that make it the most capable off-roader available. Many vehicles can take you to remote locations, but you're most likely to make it back home in a Wrangler.



VERSATILITY

FUN
TO DRIVEOFF-ROAD
ABILITY

LUXURY

PERFORMANCE

DESIGN

VALUE

FUEL
EFFICIENCY

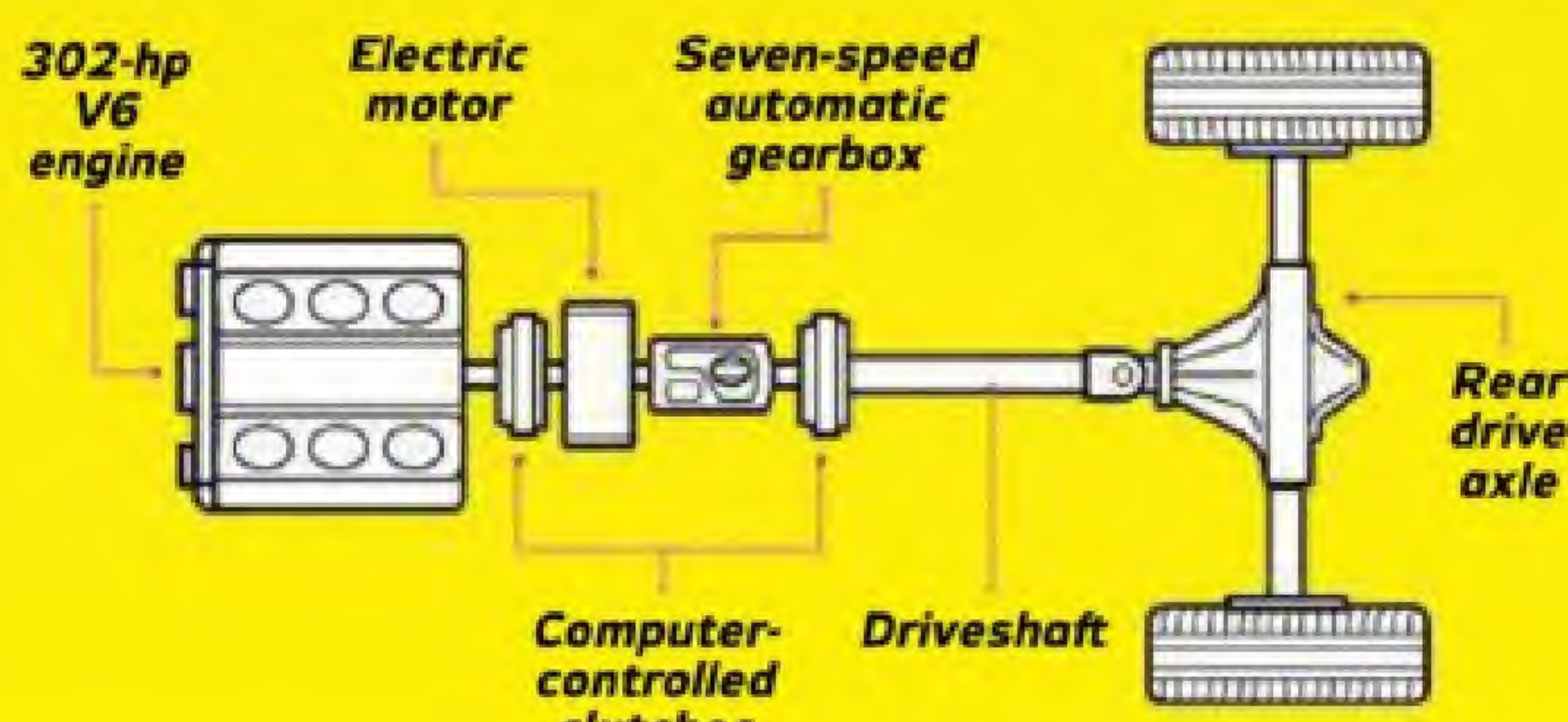
WORKHORSE

TECHNICAL
INNOVATION

LUXURY

2012 INFINITI M HYBRID

Base Price: \$53,700



We expected the Infiniti M Hybrid to save fuel. What we didn't expect was how effectively the electric motor would spice up the driving experience. The Infiniti's 67-hp electric motor complements the 3.5-liter V6 with nearly 200 lb-ft of instantaneous electric torque at liftoff. This hybrid zings, bolting to 60 mph in a little over 5 seconds.

Yet speed is not the sole goal of a luxury car. "Luxury" is loosely defined as something you don't need but want anyway. And the extra performance of the hybrid system has only increased our desire for this sedan. The gas-electric powertrain is nearly transparent in its operation. At speeds of up to 62 mph it can silently draw on the lithium-ion battery pack and electrically glide for more than a mile. The brakes—which have the tough task of integrating the standard hydraulic system with energy regeneration—feel, well, normal. Plus, the system delivers 29 combined EPA mpg, a 28 percent improvement over the nonhybrid M. During one drive, we used the Eco Pedal feature (it coaches efficient driving with gas-pedal feedback) and got over 30.

We still admire this car for its sweeping exterior, posh and nearly silent interior, engaging driving experience, reasonable price and the range of optional high-tech features (our favorite is the Lane Departure Prevention system, which brakes a single wheel to automatically keep the car in its lane). The hybrid system makes the case for the M even stronger.

The Infiniti's hybrid system relies on a pair of computer-controlled clutches to orchestrate the operation of the gas engine and electric motor. The front clutch opens for EV mode, but can quickly engage the gas engine when extra power is required.

PERFORMANCE

2012 MUSTANG BOSS 302

Base Price: \$40,955

10 REASONS WHY THE FORD MUSTANG BOSS 302 IS THE BOMB

The 2012 Ford Mustang Boss 302 is the kind of fully realized, perfectly crafted performance car that comes along only once a decade. Here, 10 reasons why we can't stop thinking about it.



1 The History Is Inescapable

The C-stripe graphics and cue-ball shifter; legendary Trans Am racing names like Bud Moore, Parnelli Jones and Kar Kraft were all connected to the Boss. It gives you chills.

2 It Sings

Side-exit exhausts with removable sound baffles are standard. They make a crackly, intoxicating howl just 3 feet beneath your ears.

3 It's Got Seats of Power

The no-cost-option Recaro sport seats feel every bit as mission critical as the naturally aspirated 444-hp 7500-rpm 5.0-liter V8 under the hood.

4 7500 rpm

Yes, you read that right. And when the rev limiter hits, the engine is still pulling. Hard.

5 Engine Awe

Consider how amazing that redline is for a big V8. While you're at it, ponder the Boss's race-engine-inspired short-runner intake manifold, which mates to ported cylinder heads.

6 It Defies Gravity

The oiling system is capable of withstand-

ing cornering loads greater than 1.0 g's. In other words, Ford wants you to hit a racetrack, mount some sticky tires and put the smack down.

7 It Makes You a Better Driver

The Boss's chassis—forgiving, capable and offering seemingly endless traction and grip—has a way of smoothing out even the most idiotic inputs and making you look like a genius. And who doesn't want to look like a genius?

8 Unlockable Content

The optional red-colored TracKey lets you tap more aggressive fuel-injection mapping and a lumpy, old-school, big-valve-overlap idle. More chills.

9 It's a Tinkertoy

Five-way adjustable dampers are standard—you can soften the car for the street or stiffen it for the track with just 5 minutes and a screwdriver.

10

\$40,995, 4.3 seconds to 60 mph, and a 12.8-second quarter-mile time.

Enough said.



Left: The exhaust side extensions exist solely to pipe that V8 soundtrack to your ears. **Middle:** The driver's compartment enhances the muscle-car experience with a suede-wrapped wheel and tight shifter. **Right:** The Recaro sport seats are a no-cost option. Get them.



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VERSATILITY | FUN TO DRIVE | OFF-ROAD ABILITY | LUXURY | PERFORMANCE | **DESIGN** | VALUE | FUEL EFFICIENCY | WORKHORSE | TECHNICAL INNOVATION



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“THE NEW A7 EMBODIES WHAT GOOD CAR DESIGN PROFESSES TO ACHIEVE: SOLID PROPORTIONS, SILKY LINES AND A LITTLE SURPRISE TO FEED OUR CURIOSITY. THE A7 DOES ALL OF THIS WITH A BEAUTIFUL TOUCH THAT SATISFIES BOTH SEDAN AND SPORT ENTHUSIASTS.”

• DESIGN

2012 AUDI A7

Base Price: \$59,250

We don't simply drive cars, we sing about them. "Mustang Sally," anyone? That intoxicating emotional pull comes from many aspects, but let's face it, our desire starts with the design. Audi's A7 debuted with an exterior that elicits stares. Since it's tough to point out exactly why the A7 captures the eye, we deferred to an expert to explain the finer points.

• **FRONT AND REAR LAMPS**

"Audi is a pioneer in light technology. Their LED components give a sense of precision, not only in the way the light is styled but also when the light is on. It is much more defined when lit."

• **ROOFLINE**

"The roofline drops straight to the rear lip of the vehicle, making the car rear-biased. Traditionally, Audi makes their cars cab-forward. The A7's lines make it appear faster and more dynamic."

• **REAR LIP**

"Audi has never really had a defined rear lip like they do in the A7. It's a nice crisp line. Look how Audi has tucked the rear lamp right up to the lip. It helps define the rear edge of the car. They've basically created a picture frame with that rear deck line and made a conscious decision to keep everything within that frame."



• **WOOD GRAIN**

"The A7 has an application of Audi's new wood grain. They stack multiple layers of wood and use the cross sections rather than just the face of a single surface. It's absolutely exquisite and kind of breaks the mold of what wood grain is."

• **GRILLE**

"The grille is a brand signature for Audi. The angle of this grille has a rake to it, giving the front end an aggressive appearance. Same goes for the lights and the sweep of the break line in the fender. You have aggression in the front of the car and aggression in the back."

• **FENDER**

"The tight break line in the shoulder begins in the fender. It comes from under the headlamp and travels up over the wheel well more dramatically than in previous Audis. It gives the proportions of the car on the front end more definition, more presence."

• **SIDE**

"There is a lot of definition and volume in the body around the wheels and through the doors. Consumers get a sense of how well-built and solid the car is based on this visual weight. This is very important in making the car feel like it's an Audi."

• **SHOULDER**

"The car's shoulder—the curvature of the body side and the area that transitions into the greenhouse—is right above the door handle. Audi has always had a strong shoulder in all of their cars, but this is a little bit tighter than we've seen in the past."



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VERSATILITY

FUN
TO DRIVEOFF-ROAD
ABILITY

LUXURY

PERFORMANCE

DESIGN

VALUE

FUEL
EFFICIENCY

WORKHORSE

TECHNICAL
INNOVATION

• VALUE

2012
HYUNDAI
ACCENT
GLS

Base Price: \$12,445

V

Value is about more than just a price tag. While its \$12,445 base MSRP puts the new Accent GLS about \$1500 above the also-new Nissan Versa, the Hyundai doesn't feel or behave like a cheap car. Start with the 1.6-liter four-cylinder, the first engine in this category that uses efficient direct fuel injection. There's a healthy 138 hp and an optional six-speed automatic transmission that comes with a manual-shift mode. The Accent also sports Hyundai's latest sharp styling

theme, and the car's interior volume of more than 103 cubic feet puts it above the subcompact competition. Thanks to a wheelbase that's 3 inches longer than before, it rides better and has a more comfortable cabin and spacious cargo hold (there's additional room in the hatchback version, but it's a bit pricier). With handsome interior trim and a long list of features, the new Accent is one of very few small, affordable cars that we'd happily take on a cross-country drive. A lot of car for the money, in other words, and we call that a great value.



• FUEL EFFICIENCY

2012
VW PASSAT TDI

Base Price: \$26,795

There's not much of Europe left in the new Volkswagen Passat. The car has been enlarged and softened for American tastes and it's even built here in a brand-new factory in Tennessee. This American-only Passat, however, is also the

only midsize sedan offered with the engine favored by Europeans: a diesel. Turbocharged for greater efficiency, VW's 2.0-liter diesel produces a measly 140 peak horsepower—but what's important is the 236 lb-ft of torque generated at just 1500 rpm. That makes the Passat TDI feel punchy and entertaining, rather than sluggishly boring. But the big wows come from its mileage numbers. Equipped with either the six-speed manual or automatic transmission, the TDI returns 31 EPA city mpg and an astonishing 43 highway mpg. In other words, the Passat gets better fuel economy than cars two classes smaller, yet it starts at a reasonable \$26,795 and has more rear legroom than the Ford Taurus. The diesel's open-road efficiency is matched to an 18.5-gallon fuel tank, so the Passat can travel some 800 miles between fill-ups. Try to make your bladder last.

VERSATILITY

FUN
TO DRIVE

OFF-ROAD
ABILITY

LUXURY

PERFORMANCE

DESIGN

VALUE

FUEL
EFFICIENCY

WORKHORSE

TECHNICAL
INNOVATION

• WORKHORSE

2012
NISSAN
NV

Base Price: \$24,950



Nissan's new NV full-size van (offered in three weight ratings: base 1500, 2500 HD and 3500 HD) brings fresh and handy ideas to the rarely changed van segment. Nissan started with a passenger cabin more like that of a pickup truck for additional room and easier access—both to the cab and underhood. Stout, durable hinges let the cargo doors swing back beside the body (243 degrees, with a stop at 90 degrees to

prevent them from swinging wildly out into traffic). A tall-body version accommodates walk-through access for tradesmen or taller cargo; a standard-height one suits those who need their 20-foot-long vans to fit under overhead garage doors. Add a best-in-class turning circle of 45.2 feet, plenty of threaded holes in the interior that make mounting racks a snap, and a relatively subdued interior, and it's a tool that doesn't feel like work to use.

• TECHNICAL INNOVATION

MAZDA SKYACTIV
ENGINES



GASOLINE
ENGINE

Mazda's new SkyActiv gasoline engine is a perfect example of small and creative improvements combining for a significant efficiency gain. Take, for example, the motor's compression ratio, which at 13:1 is about 20 percent higher than that of most other engines. Higher compression means the engine gets more work out of each combustion event, but it also increases the risk that the air-fuel mixture will auto ignite, a harmful condition known as detonation. To reduce that risk, Mazda employed direct fuel injection and an elaborate exhaust header with equal-length pipes running from the cylinder head to the catalyst. Both reduce heat—the fuel cools as it evaporates and the header scavenges the hot exhaust gases. There's also a new twist on the variable valve timing mechanism. The intake cam's actuator can rotate 180 degrees—40 is typical. So when full engine power isn't needed, the computer can leave the intake valves open during a portion of the compression stroke, which reduces the amount of air—and thus fuel—consumed by the engine. All these features, plus careful attention to reducing friction and weight, yielded a normally aspirated 2.0-liter engine that produces 158 hp and should return 40 mpg when it debuts in the Mazda3 next year.

SKYACTIV
DIESEL
ENGINE

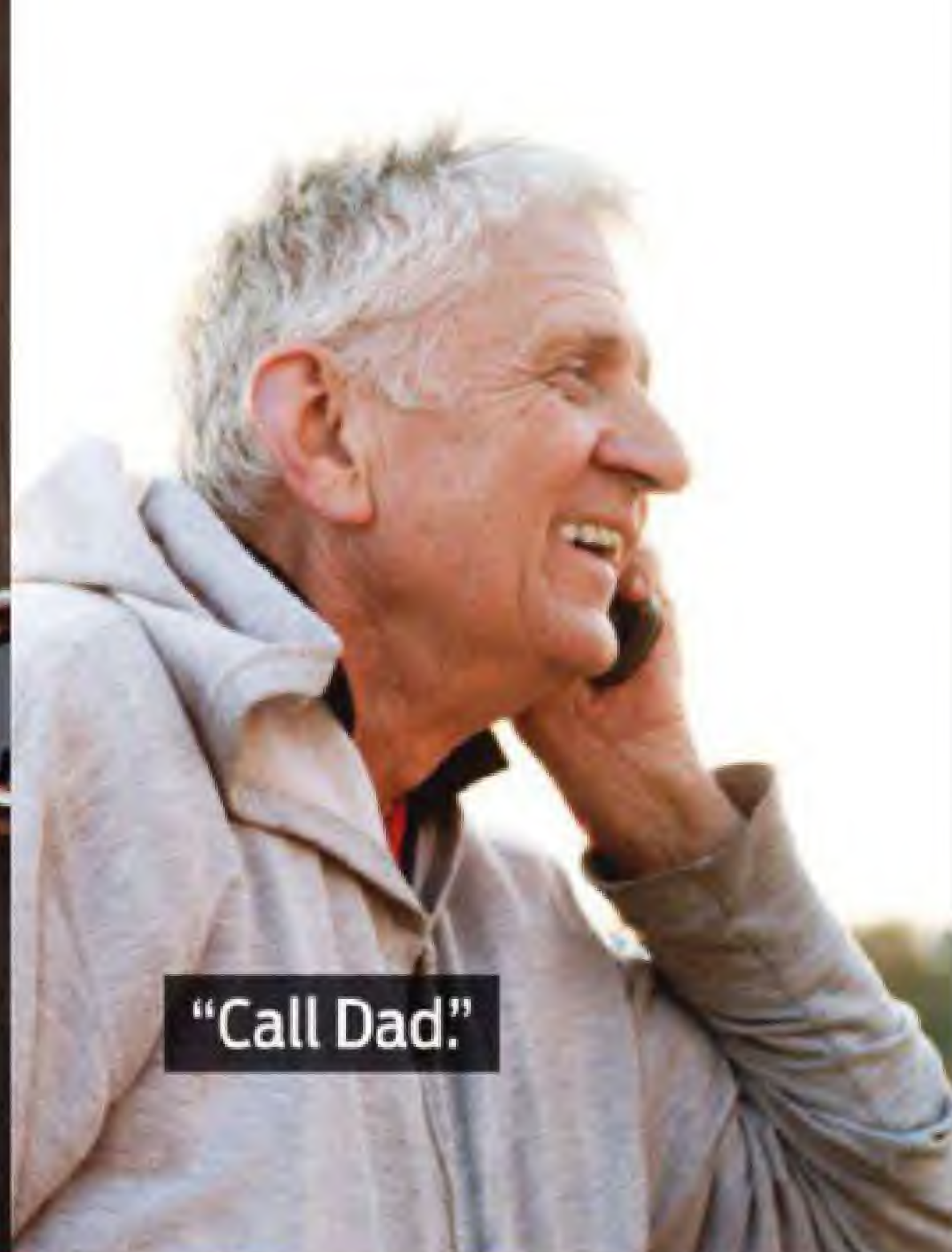
• Diesel engines are wonderfully efficient, but they require costly urea-injection systems to match gas-engine exhaust emissions. Mazda's new 2.2-liter diesel, however, meets all U.S. regulations, without urea injection. Plus, when it arrives in 2013 in the CX-5, it will produce around 310 lb-ft of torque and rev to an un-diesel-like 5000 rpm.

DIESEL
ENGINE





"Find Japanese restaurant."



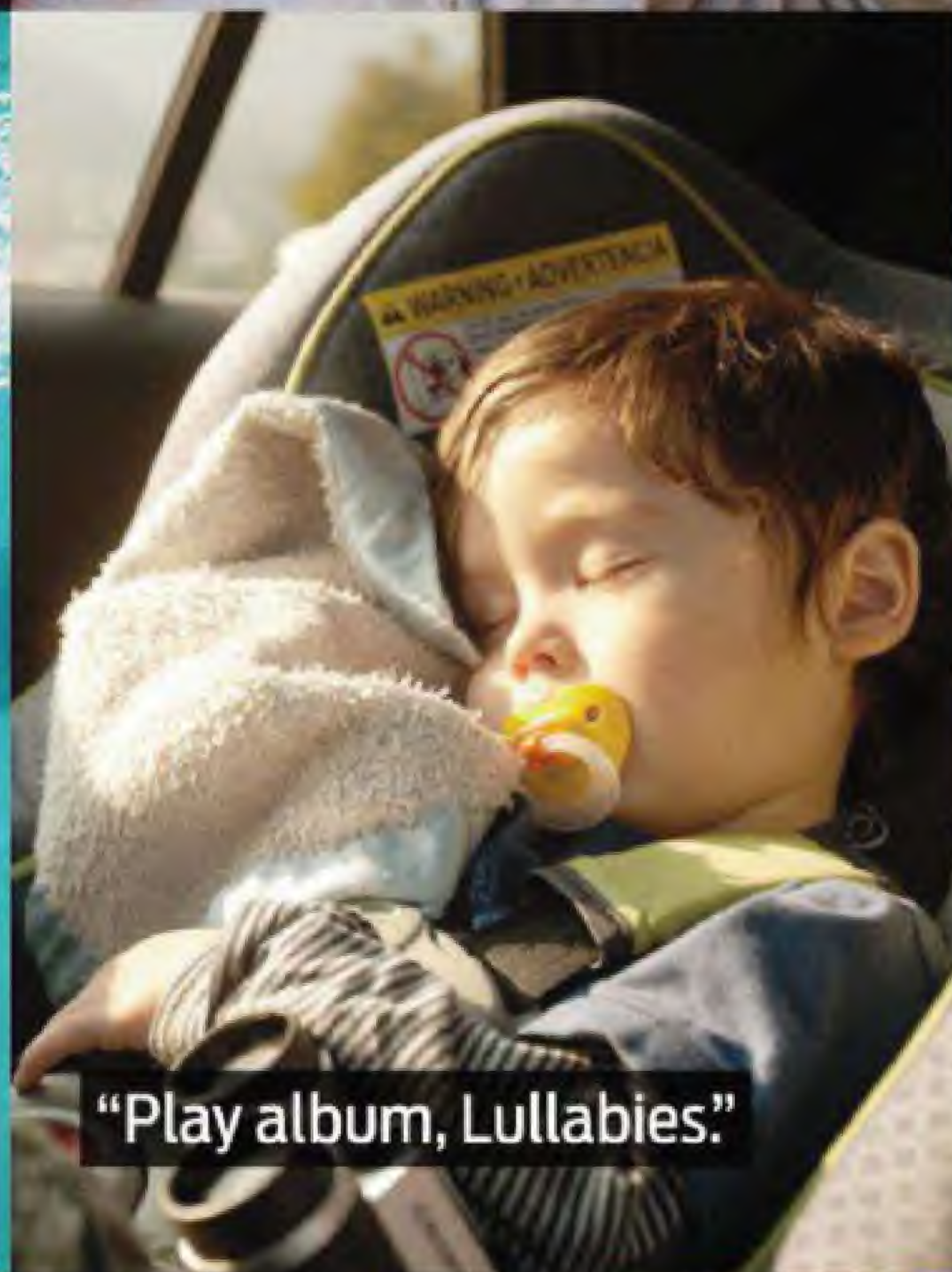
"Call Dad."



"Play artist, Johnny Cash."



"Destination zoo."



"Play album, Lullabies."



"Find a vet."



"Destination home."

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Jetpack at Last

> BY JEFF WISE
> PHOTOGRAPHS BY FILIP KWIATKOWSKI



AFTER A HALF-CENTURY OF YEARNING, PM CAN FINALLY PILOT A JETPACK. SCIENCE FICTION, MEET SCIENCE FACT.

The author blasts along a canal near Ft. Lauderdale, Fla., giving a whole new meaning to the term "hydropower."

E

EARLY ON A QUIET SUNDAY, ONLY A FEW PEOPLE are on hand to gawk as my instructor gives me a helmet and a life jacket and straps me into the sleek aluminum-and-composite frame of a jetpack. Gingerly, I make my way down a slippery boat ramp and wade out into the cool, murky water of a South Florida canal. As the bottom slopes away, I start a leisurely dog paddle. Any alligators around here, I wonder.

"Okay, engine on," says a voice in my radio earphone. "Throttle up."

I twist my right hand, and with a low rumble, the jetpack begins to move me forward through the water.

I twist more and my chest rises above the surface, then my hips. The twin nozzles clear the water with a whooshing sound like a fire hydrant turned on full blast. I continue to accelerate as my knees emerge, and then my feet. I'm completely out of the water, floating. I shift my weight to the right and ease into a gentle turn. I'm flying!

It's true: The jetpack has finally arrived. Granted, it's not the kind of rocket-powered contraption we

expected to be flying by the 21st century. Instead of hot gases, this device—the Jetlev R200—soars on thunderous towers of water that shoot down from twin nozzles. It's a bit like riding around on a pair of fire hoses. To provide that water, the nozzles are connected via a 33-foot-long hose to a floating pod containing a 255-hp engine that powers a pump. Wherever you go, your supply of high-pressure water trails behind. It's pretty noisy; the volume is comparable to a motorboat at full throttle, but it's a very different sound—more like a good-size waterfall.

Balancing atop a pair of man-made geysers sounds tricky, but the controls turn out to be quite simple. Two handlebars project forward from the frame at shoulder height. They connect to the outlet nozzles so that moving the handgrips up and down angles the thrust downward and backward. Move one handle up and the other down, and you turn. The right-hand grip also rotates like a motorcycle accelerator to control the overall thrust. The user's balance and low center of gravity provided by the weight of the water in the inlet hose keep the Jetlev upright.

Once I get the hang of balancing myself, I circle left and right, then carve a few figure eights. Keeping the Jetlev under control takes concentration. Pulling the handles down increases your forward speed but reduces lift, so to compensate you have to throttle up at the same time or

else you'll lose altitude. Still, after about 5 minutes I'm comfortable enough with the controls that I can trace a wobbly path up and down the canal, rising and sinking as I go.

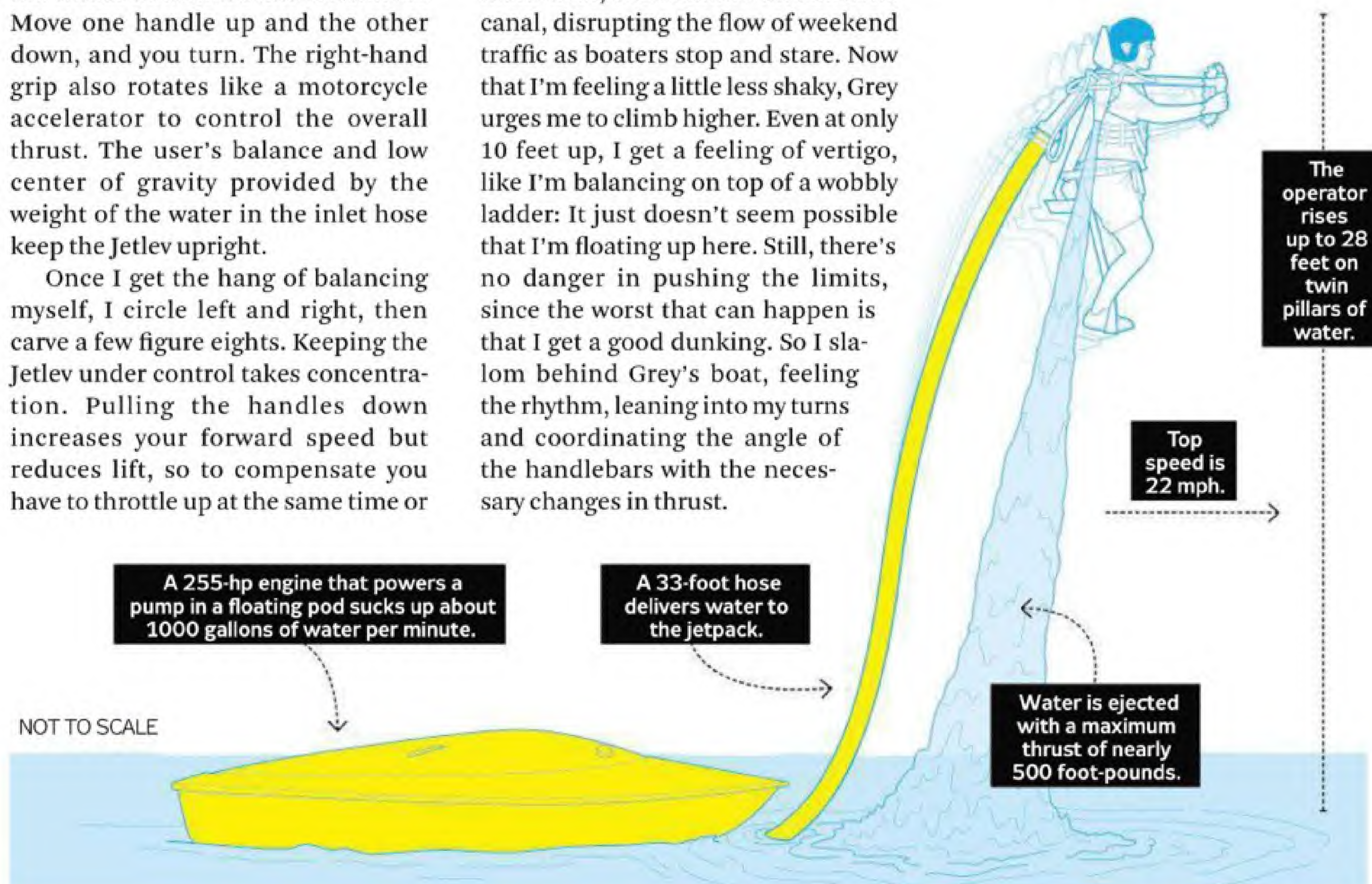
In the hands of a capable operator, the Jetlev can wander hither and yon, pulling its floating pump behind it at speeds up to 22 mph. The hydrogen-peroxide-powered Bell Rocket Belt, a device that was developed for the military and worn by James Bond in *Thunderball*, stayed aloft for only about 20 seconds. The Jetlev can fly for hours at a time. You're more likely to run out of gas before it does.

Within 15 minutes, in fact, my arms are painfully tired. Beginners, apparently, grip the controls too tightly. I throttle down, settle into the water near the ramp and take a breather. While I rest, Jetlev chief pilot and instructor Steven J. Grey takes the machine and begins maneuvers, leaping skyward straight from the dock, plunging below the surface, then skimming over it like a torpedo before zooming vertically like a launching missile. Cool? Very.

As soon as I can lift my arms again, I strap back in. Grey hops into a motorboat, and I follow him down the canal, disrupting the flow of weekend traffic as boaters stop and stare. Now that I'm feeling a little less shaky, Grey urges me to climb higher. Even at only 10 feet up, I get a feeling of vertigo, like I'm balancing on top of a wobbly ladder: It just doesn't seem possible that I'm floating up here. Still, there's no danger in pushing the limits, since the worst that can happen is that I get a good dunking. So I slalom behind Grey's boat, feeling the rhythm, leaning into my turns and coordinating the angle of the handlebars with the necessary changes in thrust.

Then I make a turn a little too fast and a little too high and realize that I actually could hurt myself: I could fly into something solid. All at once I'm closing in on the back of the boat, and in my sudden surge of panic I can't seem to remember how to work the controls. Fortunately, I remember rule No. 1: When in doubt, cut the power. I crank the throttle back and cannonball into the canal. Stroking upward through the murky brine, I've never been so happy to have water shoot up my nose.

A twist of the handle, and I'm back in the sunshine, dripping and smiling from ear to ear. I've experimented with lots of cockamamie contraptions, and most of them have come up short. The Jetlev is different. Not only is it a remarkably successful piece of engineering, but the experience it offers is the most exhilarating thing I've tried since surfing. Sure, the \$99,500 price tag may be a tad steep for the average weekend warrior. But I think beachside rental shops will have little trouble finding customers. It turns out that after waiting all these years for our jetpacks, they really are as fun as we imagined. **PM**



X-PLANE

RISING



BY JOE PAPPALARDO

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X-47B

WINGSPAN: 62.1 FT

LENGTH: 38.2 FT

THE FUTURE OF NAVAL AVIATION MAY NOT BELONG TO PILOTS. THE PENTAGON IS DEVELOPING A CUTTING-EDGE WARPLANE THAT CAN OPERATE FROM A CARRIER WITHOUT AN AVIATOR OR REMOTE CONTROLS. WILL UNMANNED AIRCRAFT END THE ERA OF TOPGUN?

FOR ENSIGN KYNDRA CHITWOOD, LEARNING HOW TO FLY blind is just part of becoming a U.S. naval aviator.

The 23-year-old strides across the flight line at Naval Air Station Whiting Field. Around her, dozens of orange and white T-34 Mentor training aircraft are lined up, fuselages gleaming in the Florida sun. Pairs of student-trainer teams in flightsuits are making their way to and from the aircraft. A formation flight of two T-34s cruises overhead, wingtip to wingtip.

Chitwood is readying herself for a tense afternoon in the air. A typical five-day week at Whiting, 25 miles northeast of Pensacola in

Northrop Grumman is making the Navy's newest experimental warplane, a carrier-ready unmanned aircraft called the X-47B, shown here during structural stress tests at the company's facilities in Palmdale, Calif.

the Florida panhandle, features daily flying tests; each is a high-pressure evaluation. Today Chitwood must prove she can pilot the T-34 using instruments alone.

Just after takeoff she will pull a nylon hood across half of the cockpit canopy to block her vision, then steer the single-engine prop plane through landing approaches at several civilian airfields. She will be asked to demonstrate her ability to use GPS signals, UHF transponders on the ground and radio commands from radar operators.

Within 40 minutes of suiting up, Chitwood and her instructor are cleared for takeoff. The aircraft buzzes down the runway and sails into the sky, banking toward Marianna Municipal Airport, 120 miles east. She would normally handle takeoff on her own, but the instrument tests require that she sit in the T-34's back seat, so her instructor guides the aircraft into the air.

The clouds are so thick she can't see the horizon, so there's no need to pull the hood closed. Once her instructor removes his hands from the controls, the day's aerial evaluation will begin.

Primary flight instruction here is the start of a process that makes U.S. naval pilots the best in the world. Every student in the class is graded on a bell curve, and those who score highest usually get first choice of flight assignments.

These aviators are jockeying against one another for seats in cockpits, but the generation of naval pilots after Chitwood may be grounded by new competition: robots. The Navy is aggressively researching the use of unmanned aerial vehicles (UAVs) for jobs now performed by people. By the time a pilot like Chitwood retires in 2030, assuming a full career, there could be a lot fewer aircraft for her replacement to fly.

DOG FIGHT FOR THE FUTURE

STRIKE FIGHTERS ARE THE TEETH of an aircraft carrier, protecting the ship from aerial threats and attacking targets on the ground. The idea that UAVs can perform these missions is heretical to officials who say that a carrier deck is too complex for an unmanned aircraft. But the orthodoxy is changing, and two naval aircraft are now vying for future dominance.

Ensign Kyndra Chitwood doesn't believe her career as a Navy pilot is threatened by unmanned aircraft. "It's hard to integrate them into the fleet," she says.



In one corner, there's the Navy's marquee future warplane, the F-35C Lightning II. A product of the Joint Strike Fighter program, the F-35C will be the Navy's first stealth aircraft. At \$133 million per airplane, it is the most expensive defense program in the world.

The JSF program started in 1996; five years later, Lockheed Martin beat Boeing for the multibillion-dollar contract. The program is producing three F-35 variants: one for the Navy, another for the Air Force and a short-takeoff and vertical-landing version for the Marine Corps. Each aircraft is now nearing the end of a tortured development—years late and tens of billions of dollars over budget.

In the opposing corner is the X-47B, an experimental airplane with something to prove. Even though it's just a demonstrator, it has folding wings that enable it to fit inside a carrier's hangar, twin weapons bays and the ability to fly at high subsonic speeds. The program started in 2000 as one of two \$2 million concept studies, but the UAV is no longer a line-item underdog.

The X-47B is a testbed supporting the \$2.5 billion Unmanned Carrier Launched Airborne Surveillance and Strike program. UCLASS may result in an unmanned aircraft that can perform the same missions as the F-35C but would stay in the air longer and be harder to spot on radar.

When he was selected to head the X-47B program in late 2010, Capt. Jaime Engdahl thought the UAVs would be remotely piloted onto the deck with a joystick. "I didn't even realize, until I really started digging, how advanced some of the things that we're doing are," he says. "This is, no kidding, making an air vehicle that's autonomous and as self-sufficient as a naval aviator."

A few years ago, predictions that the F-35C would be the last piloted Navy fighter seemed overly dramatic. But as the X-47B progresses, the prediction is more realistic. The Navy will not deploy the F-35C on a carrier until late 2016. The Pentagon plans to integrate strike UAVs into the fleet by 2018.

Despite stalwart support from Navy brass, politicians are considering trimming the F-35C and other JSF variants: In 2010 the National Commission on Fiscal Responsibility and Reform (Bowles-Simpson Commission) recommended halving orders of F-35Cs.

There are signs that the budget crisis may change the landscape

ILLUSTRATIONS BY TAMER KOSELI

"MY THINKING IS THAT [UAV ADOPTION] IS TOO DAMN SLOW. WE'VE GOT TO HAVE A SENSE OF URGENCY ABOUT GETTING THIS STUFF OUT THERE."

ADM. GARY ROUGHHEAD, CHIEF OF NAVAL OPERATIONS

THE
CONTENDERS

High-performance strike airplanes are the A-list celebrities of the Navy. These warplanes must be tough enough to handle the stress of catapult launches, sophisticated enough to evade electronic attack, rugged enough to withstand salty ocean air, nimble enough to dogfight a MiG and deadly enough to eliminate ground targets with precision. Four U.S. Navy warplanes fit these criteria; all are vying for primacy as the Navy reshapes its future.



NAME Phantom Ray
MANUFACTURER Boeing
SELLING POINT The company completed its first experimental stealth UAV, the X-45A, in 2000 and sporadically improved the prototype.
STATUS In 2011 Boeing paid for Phantom Ray test flights, positioning itself for a pending Navy strike-aircraft competition.



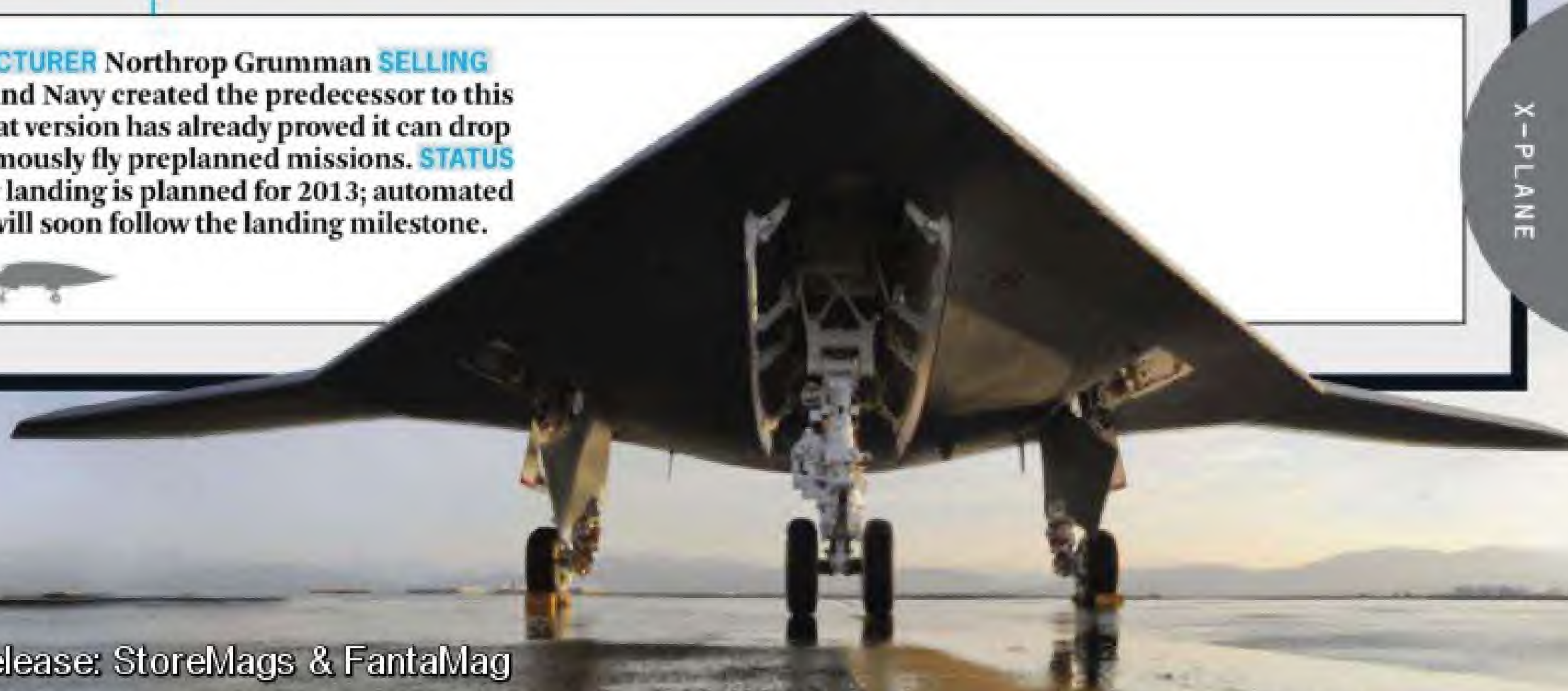
NAME F-35C Lightning II
MANUFACTURER Lockheed Martin
SELLING POINT The F-35C, the carrier variant of the Joint Strike Fighter, is the most sophisticated warplane ever built. Pilots will be able to see threats from 360 degrees and access targeting data from other aircraft and ground sensors.
STATUS After years of delays, the F-35C may deploy in 2016. Congress is considering cutting the number of planes it orders.



NAME F/A-18E/F Super Hornet
MANUFACTURER Boeing
SELLING POINT The Super Hornet, fielded in 1999, has made a career filling the gaps left by failed fighter programs. Although it's not a stealth aircraft, designers shaped the airplane to reduce its radar cross section.
STATUS As the F-35C faced delays, the Navy ordered more F/A-18s.



NAME X-47B
MANUFACTURER Northrop Grumman
SELLING POINT The Air Force and Navy created the predecessor to this demonstrator, and that version has already proved it can drop weapons and autonomously fly preplanned missions.
STATUS The UAV's first carrier landing is planned for 2013; automated aerial refueling tests will soon follow the landing milestone.



A 100-YEAR
RELATIONSHIP

POPULAR MECHANICS reported in 1914 that the British were constructing ships built specifically to accommodate airplanes and designing these “flying boats” with folding wings so they could be more easily stowed at sea. From these humble beginnings, naval aviation has come to dominate global affairs. The ability to protect allies and interests around the globe depends on delivering air power quickly and without reliance on airfields. The missions of naval aviators go beyond airstrikes; helicopter pilots hunt submarines, prop planes gather intelligence and jets protect troops on the ground. It’s been a busy 100 years; below are a few highlights.



Eugene Ely takes off from a wooden platform affixed to a ship's deck. In 1911 he makes the first landing; naval aviation is born.



Lt. Virgil Griffin, in a Vought VE-7SF biplane, becomes the first to fly from the Navy's first aircraft carrier, the USS *Langley*.

The Navy defeats the Japanese in the decisive Battle of Midway. Carrier-based American warplanes sink five Japanese warships; the U.S. loses a carrier and a destroyer.

Instead of supporting fleet operations, naval aviators during the Korean War (1950–53) dedicate the majority of their flights to supporting ground forces. Their contribution is large: On the last day of the war, 21 squadrons fly missions from four aircraft carriers.

During the Vietnam War, aviators in Navy F-4s shoot down 24 enemy MiGs in 1972 alone.



1910

1922

1942

1953

1972

Since the 1980s the combat radius* of Navy warplanes has declined, largely in part because of heavier payloads of weapons and advanced sensors. Midair refueling aircraft can extend missions, but most refuelers are based on land and vulnerable to attack. New technology has increased the combat radius of naval aircraft; unmanned strike aircraft are expected to triple the fighting range of an F-14 Tomcat.

* INFLUENCED BY ALTITUDE AND MISSION PROFILE

F6F-5 Hellcat
Deployed: 1943
Bomb load: 500 lb

F-14 Tomcat
Deployed: 1974
Bomb load: 15,000 lb

CARRIER

Combat radius: 340 nautical miles
(drop tank only)

500 nm

within the Navy. *Aviation Week* obtained a 2011 memo from U.S. Navy Undersecretary Robert Work asking Navy brass to seek alternatives to the F-35C. (He also asked the Marine Corps to examine the impact of eliminating the problematic F-35B.) The response will be ready for the 2013 budget.

The Navy's need for the F-35C and the new UAVs is based on the emergence of fresh threats. Any future strike aircraft needs to be stealthy—advanced radar and anti-aircraft missiles make strike and surveillance missions dangerous.

There are other threats that will likely force carriers to operate at greater distances from targets. China is fielding submarines that can lurk in the shallows,

where side-scan sonar is less effective. These quiet subs are armed with sea-skimming missiles that can slip past a ship's defenses. The Russians build and sell sophisticated warplanes that can venture from air bases on land to swarm a carrier and its escorts with air-to-ship missiles.

The emergence of these close-to-shore threats is bad news for the Navy because the reach of its strike aircraft has been decreasing since the 1980s. The F-35C's 640-nautical-mile combat radius will reverse the trend, but UAVs such as the X-47B easily double that distance.

And there's another metric to consider: the amount of time a stealth warplane can linger over a target. The military calls this attribute persistence. A



The movie *Top Gun* is released; its popularity helps drive a year-long increase of 16,000 recruits in the Navy.

During the Gulf War, ship-launched Tomahawk cruise missiles prove themselves as alternatives to airplanes. Manned Navy planes take out Iraqi air defenses and devastate military vehicles.

U.S. naval warplanes strike targets inside Afghanistan from the Arabian Sea; for diplomatic reasons, attacks can't be launched from air bases in the region. Flights, some 10 hours long, require aerial refueling from Air Force tankers.

Engineers lay the keel of the new U.S. supercarrier, the *Gerald R. Ford* (CVN-78). It will launch more sorties but will require hundreds fewer crew. Delivery is scheduled for 2015.

The X-47B makes its first flight in California. Deployment for an unmanned strike aircraft is set for 2018, but some leading Navy officials want it sooner.

F-35C, the carrier variant of the Joint Strike Fighter, takes off from a runway on its maiden flight in June. It will be deployed in 2016.

1986

1991

2001

2009

2010

2011

F/A-18C/D Hornet
Deployed: 1987
Bomb load: 13,700 lb

F-35C Lightning
Deployed: 2016 (est.)
Bomb load: 4500 lb (internal only)

X-47B prototype
Deployed: 2018 (est.)
Bomb load: 4500 lb

335 nm

640 nm

1500 nm (est.)

manned aircraft's persistence is limited by the endurance of the human onboard. A weaponized UAV, on the other hand, can track a target for dozens of hours in protected airspace and then drop a precision weapon on command.

"My thinking is that [UAV adoption] is too damn slow," Adm. Gary Roughead, chief of naval operations, said during a speech in August. "We've got to have a sense of urgency about getting this stuff out there."

WHERE ROBOTS GET THEIR WINGS

THIS JULY, LT. JEREMY DEBONS MADE AVIATION history by doing nothing at all. DeBons, call sign Silas,

flew a one-of-a-kind F/A-18D through the vast Atlantic test range off the coast of Virginia. His destination: the aircraft carrier USS *Eisenhower*. The F/A-18D and the carrier were loaded with a slew of sensors that enabled the warplane to land on the carrier's deck without any piloting from the cockpit or remote operation by the ship's crew.

The F/A-18D was a surrogate for the X-47B demonstration aircraft. The goal of the summer tests was to prove that the brains of a robot can guide a warplane to a carrier's pitching deck. If this demonstration program succeeds, the Navy can proceed with the UCLASS procurement. After the X-47B becomes carrier-ready, it will then autonomously rendezvous

with aerial refueling tankers.

Future unmanned aircraft will not be flown by crews via joystick, as Air Force personnel currently operate MQ-1B Predators. Once launched, a UAV following a prearranged mission plan will use onboard sensors to avoid other aircraft and dodge enemy attacks. It will also identify targets in the air and on the ground and track them without direct command. (These UAVs will contact controllers for permission to release weapons.)

Landing on an aircraft carrier is one of the most difficult feats of aviation, requiring a clever mesh of man and machine. The Navy is building the X-47B's landing capability on technology pilots use today, the Precision Approach Landing System. PALS uses SPN-46 radar to locate an aircraft in relation to a carrier.

To perform the occasional hands-off landing, such as when weather obscures the ship, an F/A-18 pilot can couple the plane's autopilot with PALS data. But the PALS radar covers only the rear of the carrier and is limited by the number of aircraft it can track simultaneously. These deficiencies make it unsuitable for controlling UAVs that are approaching to land.

Instead, the Navy's robotic landing system relies on precise GPS coordinates to obtain 360-degree coverage and automate navigation. The airplane calculates the appropriate flight paths around the ship as the carrier supplies the vessel's speed, the sea state and other data.

The concept behind the X-47B is to replace pilots—but not a ship's crew. As with other carrier-

borne aircraft, the final approach of the unmanned vehicle would be monitored by the personnel onboard. Officers on the flight deck, the air traffic controller seated under the deck and officers peering from windows in the carrier's island all play a part in guiding the UAV.

Pilots most often talk with the ship by radio, but for a UAV verbal communication is replaced by digital commands. The carrier's air traffic controllers do the same job as an ATC crew in a civilian airport tower—if the runway were constantly changing location, the aircraft loaded with live weapons, and the process designed to produce as few electromagnetic emissions as possible to avoid detection.

"There's no benefit in changing the way we do deck handling," says Adam Anderson, who heads the carrier integration portion of the X-47B program at Patuxent River, Md. "We're looking at ways to make the least amount of impact. We want a paradigm shift in the number of missions the aircraft can do, but to have no shift in the way it lands."

DeBons's test flights on the *Eisenhower* went perfectly—the F/A-18D glided across the deck with its nose angled up until a hook on its tail snagged a cable stretched across the deck and jerked the aircraft to a halt. Still, the Navy test pilot says his hands never strayed too far from the controls.

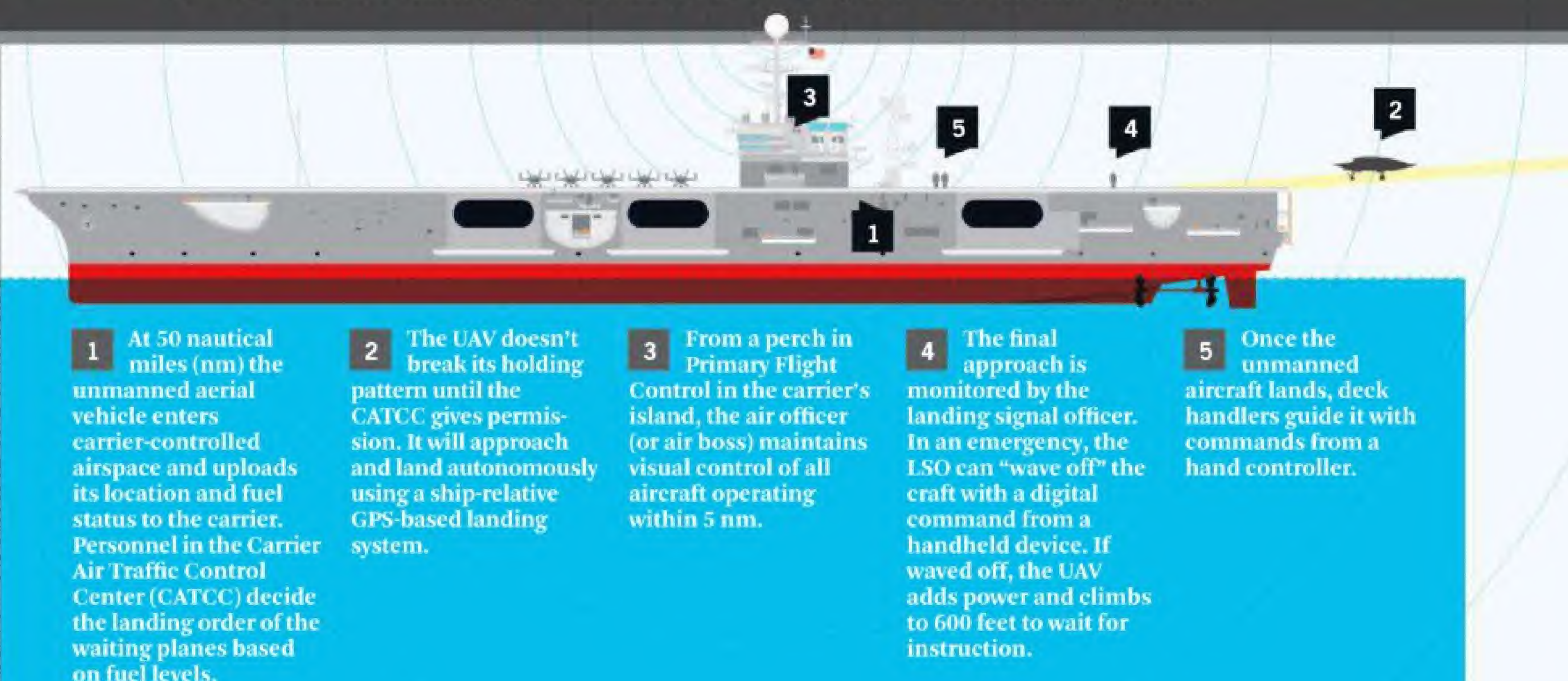
"It wasn't anything new, perspective-wise, in the cockpit," DeBons told reporters after the flight. "But being a new system, as any test pilot will say, we're always on guard."

X-PLANE

HOW IT WORKS

UNMANNED AIRCRAFT TRAPS

Navy robotic aircraft will operate autonomously, but they will still require people onboard to land. "Carrier naval aviation is extremely safe for the level of risk," says retired Rear Adm. Craig Steidle, the former head of the Joint Strike Fighter and F/A-18 programs. "The Navy is slow to evolve, which is fortunate because we have a very safe and effective system."



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HUMAN/UAV COEXISTENCE?

THE X-47B'S NEXT BIG MILESTONE IS A SERIES of aircraft carrier launches and landings in 2013. That is the same year that the F-35C will operate for the first time on a carrier, making its initial sea trials.

A technology demonstrator is a long way from a production-ready warplane like the F-35C. Even the most gung-ho Navy official extolling UAVs also expresses support for the Lightning II. "As rapidly as we want to engage with the unmanned systems on carriers, we are also moving forward with an incredible capability in the Joint Strike Fighter," Roughead says. "We've got to get that aircraft."

The pilot is the F-35C's main limitation, but the human being in the cockpit may also be its salvation. The F-35C is designed to accommodate and enhance the most powerful processor available—the human brain. The aircraft's external sensors are patched directly into the pilot's helmet, allowing him to see 360 degrees by synthesizing data from the sensors, including six infrared cameras and radar. In short, there has never been a better airplane for picking targets and seeing threats.

"Target recognition often involves the generation and interpretation of high-resolution images," Owen Cote Jr., the associate director of MIT's Security Studies Program, wrote in a recent report. "At some point in the future it may become possible to automate that process, but today, and for a number of years, target recognition will require people to interpret the images . . . It is difficult to imagine automating this."

Others caution putting too much faith in stealthy UAVs as a solution to every tactical and budgetary problem at the Pentagon. "If you canceled the F-35 you would have to do something else," says Douglas Barrie, military aerospace senior fellow at the International Institute for Strategic Studies. "Do you kick off a whole new development program with all the inherent risks and costs that you've just gone through with the F-35?"

It appears that the Navy's near future will focus on human-robot teaming. The F-35C and UCLASS will operate from carriers simultaneously and fly missions next to each other in tomorrow's conflicts. "No platform fights alone anymore," says Edward Timperlake, a former analyst of emerging technology for the office of the secretary of defense. "It's a synergy between manned and unmanned."

But as time goes on, UAVs will become more capable and the ratio of manned to unmanned missions could dramatically shift in favor of the machines. "The era of manned airplanes should be seen as over," the Brookings Institution's Michael O'Hanlon says, echoing other military analysts.

Few young pilots see a threat looming. After all, the number of people the Navy needs to fly is holding



Whether it succeeds or fails, the X-47B will earn a unique place in aviation history. It either will be the first strike UAV to operate from a carrier deck or, by failing, will push the momentum back to manned Navy warplanes.

steady. The students at Naval Air Station Whiting Field say their careers remain unclouded by robotic competition.

"I don't see anyone concerned about the community shrinking," says Lt. j.g. Bobby Lennon, who finished training at Whiting in August and will fly an MH-60S Knighthawk helicopter. "Maybe this will affect the jet guys more."

But the Navy's effort goes beyond the X-47B. The service is investing \$8 billion over the next five years in a family of unmanned UAVs. For example, the Navy plans to retire fixed-wing EP-3 Aries signals intelligence reconnaissance planes and replace them with unmanned aircraft by 2020. The Navy is already operating unmanned reconnaissance helicopters—one was shot down during combat operations in Libya—and it is constructing larger ones to carry cargo and arming others with air-to-surface missiles.

Chitwood, who aced her instrument flight examination over Marianna Municipal and Tallahassee Regional airports, is also unfazed by the emergence of UAVs. "I'm not really worried," she says. "It's hard to integrate them into the fleet. Maybe when I'm close to being done flying I'll see the effect."

It doesn't seem fair to bring up the Navy's unmanned programs when face to face with young aviators. That's policy talk, and every new Navy pilot is solely focused on the work. For them, earning the right to do the job is the only tomorrow that matters. **PM**

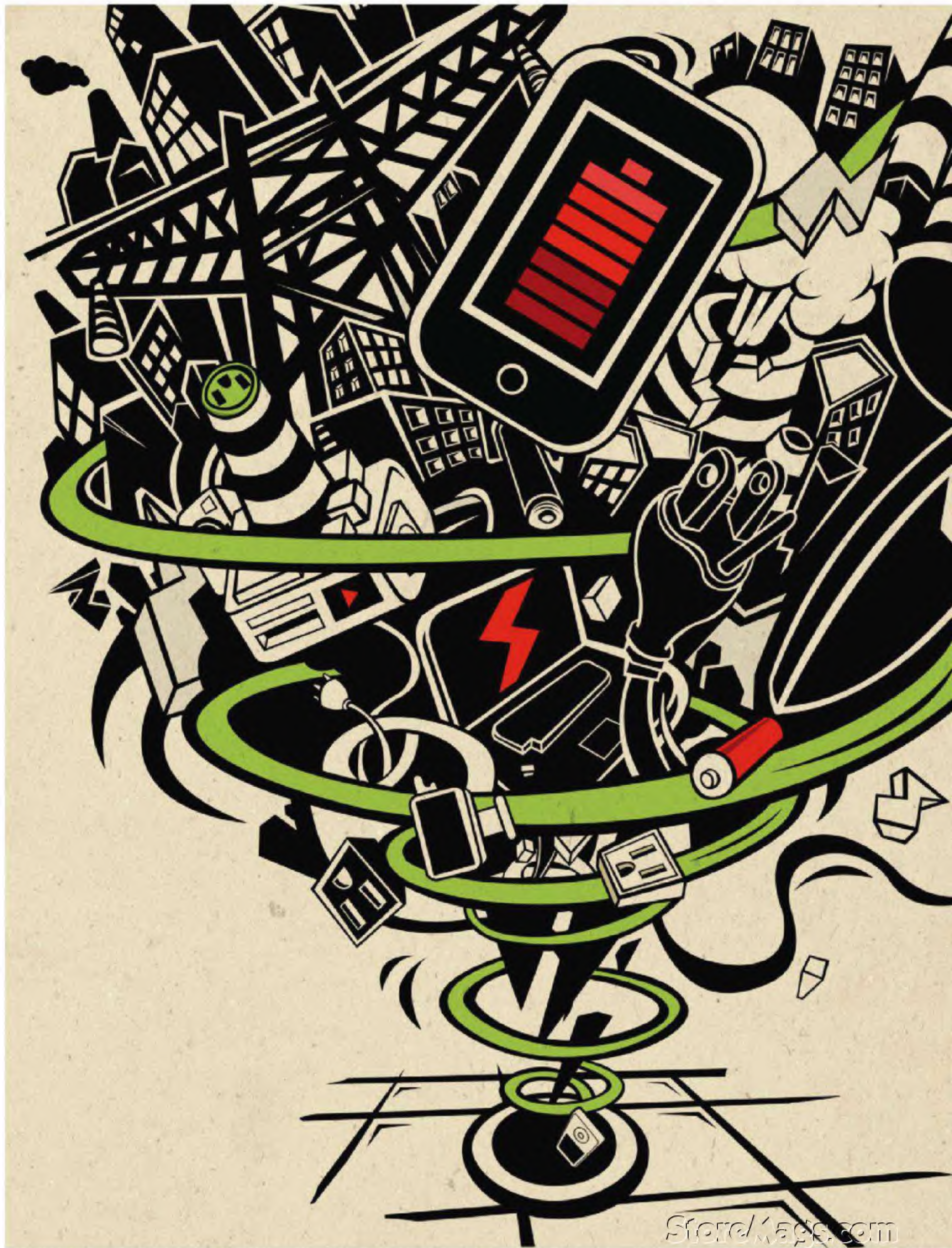
ADDITIONAL REPORTING BY SHARON WEINBERGER

LET'S GO FURTHER ON ONE GALLON OF FUEL.

We must learn to use energy more efficiently. For 25 years, the Shell Eco-marathon® has supported teams worldwide who explore ways to maximize fuel economy. Last year's winner was capable of traveling 8,870 miles on the equivalent of one gallon of fuel. This spirit epitomizes our relationship with car manufacturers, finding ways to make cars more efficient. And it's typical of our ambition to help build a better energy future. www.shell.us/letsgo

LET'S GO.





We're throwing away energy...

SOLVING OUR ENERGY PROBLEMS ISN'T JUST ABOUT PRODUCING MORE POWER, OR USING LESS. IT'S ABOUT GETTING THE MOST OUT OF WHAT WE ALREADY HAVE.

BY **ALEX HUTCHINSON** ILLUSTRATIONS **KONRAD KIRPLUK**

ONCE YOU KNOW WHERE TO LOOK, IT'S EVERYWHERE—dissipating, leaking away, drifting up in a puff of smoke. “When I see exhaust pipes and chimneys, I see wasted thermal energy,” says Chris Nelson, president of Cyclone Power Technologies in Pompano Beach, Fla. Nelson, whose father, Richard, co-founded Cogenix Energy Systems, a pioneering combined-heat-and-power company, back in 1980, grew up hearing about squandered energy—and how to recapture it—over the dinner table. Now Cyclone is preparing to unveil a universal Waste Heat Engine that can generate electricity from the exhaust pipe of virtually any small-scale industrial engine or furnace. That may make the younger Nelson the first and only second-generation energy scavenger in America. If we're smart, he won't be the last.

How we'll fuel our future is often framed as a misleadingly simple, two-sided debate: We either have to produce more energy or use less. But that picture ignores a basic thermodynamic truth: For the same reason you should never pay cash for a perpetual motion machine, you can never make use of 100 percent of the energy you consume. Something is always lost in the conversion from fuel to work. While that may sound like bad news, it also introduces a third way to address future energy needs. Right now, our energy conversion is abysmal, nowhere near the theoretical limits of efficiency. But with smarter design and new technologies, we can get a lot closer to those limits.

Consider a simple action like walking down the street. The energy that fuels you originally comes from the sun and is stored by photosynthesis in the form of chemical bonds. “It turns out that food has about 100 times as much energy per unit mass as lithium batteries,” says Max Donelan, head of the Locomotion Laboratory at Simon Fraser University in Vancouver, British Columbia. That means the average person can store as much energy as a 1-ton battery can. But the process of converting

those chemical bonds into muscle contractions wastes much of the stored energy. The remainder is used to accelerate and decelerate your limbs—and that deceleration can be scavenged to generate power much like the regenerative braking in hybrid cars: Donelan has developed a lightweight knee brace that generates 12 watts of power from the simple act of walking—enough to give a cell-phone 30 minutes of talk time after just 1 minute—with no extra effort.

The curse of inefficient conversions plagues everything from microchips to massive factories and power plants. When you boot up your laptop, the microprocessor inside is spewing heat that has to be dissipated by a heat sink and fan; the power brick that you plug into the wall is leaking energy in the conversion from AC to DC; and about 7 percent of the electricity generated at a distant power plant is wasted in transmission losses while traversing the grid before the juice ever reaches your home. The most common form of waste energy by far is heat, but power can also be squandered in unproductive motion (as in walking) or even in the millions of tons of edible food tossed into landfills. A 2010 University of Texas study estimated that discarded food contains more than 2000 trillion Btu of embodied energy each year.

No single solution can address all these different types of waste. Instead, we need to engineer creative approaches to fit each situation, as the University of New Hampshire learned after installing a gas-fired cogeneration plant in 2006. “The plant completely changed the way we think about managing energy on campus,” says Paul Chamberlin, the university’s assistant VP in charge of energy and campus development. The obvious gain was capturing excess heat that the turbine gave off while producing electricity and using it to heat campus buildings, boosting the generator’s overall efficiency from 35 percent to a maximum of about 85 percent. Better yet, the university realized that landfill gas from a nearby dump, which otherwise would have simply flared into the atmosphere, could provide valuable extra fuel. Less obvious, though, was what to do with all that extra heat in the summer—“free steam,” as Chamberlin puts it. The solution: The new UNH business school currently under construction will have steam absorption chillers instead of electric air conditioners, and other campus buildings will follow suit.

The biggest obstacles facing the quest for efficient energy conversion aren’t just technical. We have an awareness problem. When it comes to curb appeal, a nearly invisible diode that converts AC to DC with virtually no loss can’t compete with a shiny solar panel, even though the latter is less efficient. And, as a rallying cry, “Run your engine as close to the Carnot efficiency limit as possible without violating the second law of thermodynamics” will never replace “Drill, baby, drill!” So a philosophical shift is in order. Yes, we need to keep pursuing new energy resources, but we must also make the most of what we have now. “When it comes to solving our problems with fossil fuels and the environment, these technologies are really the low-hanging fruit,” Nelson says. “They’re available now; they just need to be pushed.”

... and
here's
how
to get
it back

Throwing it away:

Vibrations

Whether in bridges, shoes or keyboards, large movements beget smaller ones—most of which go to waste.

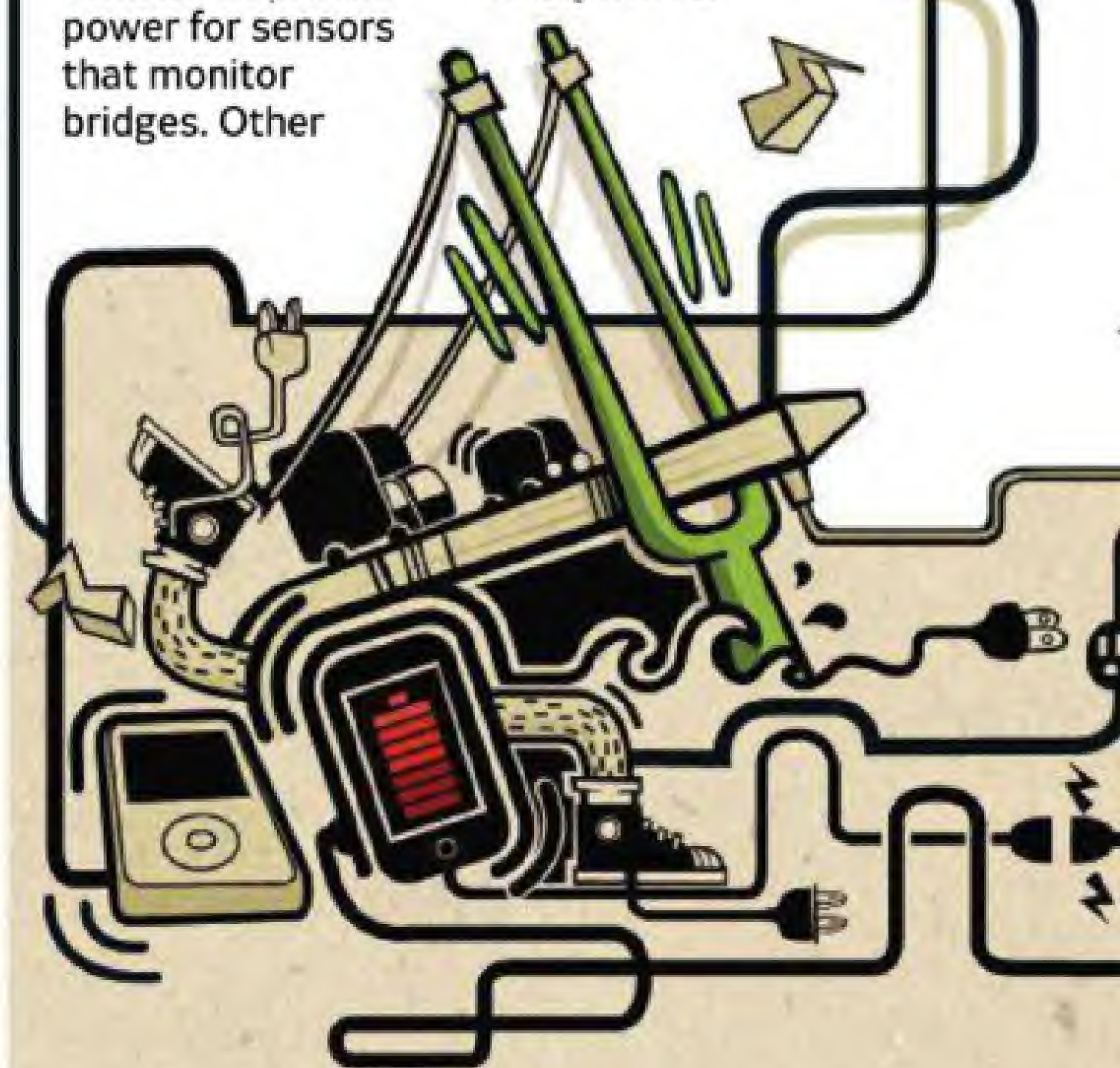
Getting it back:

PIEZOELECTRICS

+ 3 MICROWATTS PER DEVICE

In November 2010, Georgia Tech researchers built the first nanogenerator capable of powering portable electronics. A simple squeeze of the fingers generated 3 microwatts, enough to light up a liquid crystal display. The generator contains zinc-oxide nanowires, which are piezoelectric, meaning that they create electricity when stressed or deformed. The first proposed application of the new nanogenerator is harvesting vibrations from passing vehicles to provide power for sensors that monitor bridges. Other

researchers have been pursuing similar goals. Princeton University scientists have developed “piezo-rubber” that they hope will power implantable pacemakers, eliminating the need to replace batteries. Engineers at Louisiana Tech University have even built a piezoelectric generator into the heel of a shoe. The amount of power harvested by these vibration generators is small—but if they become cheap enough, they could be deployed, well, everywhere.



Computer Processing

The same inefficiencies that warm our laptops are a serious problem for data centers and supercomputers.

PYROELECTRICS

+ 8 WATTS PER CHIP

Modern computer chips face two related problems: They consume too much power and turn too much of it into heat. In fact, businesses around the world already spend \$30 billion a year powering their data centers. Turning excess heat into electricity attacks both problems at once; that's what a new pyroelectric device developed at the Department of Energy's Oak Ridge National Laboratory aims to do. Not to be confused with better-known thermoelectric materials, pyroelectric materials generate a small voltage from changes in temperature. The device relies on a tiny cantilever that oscillates between the hot computer chip and a pyroelectric heat-sink, removing heat and generating electricity with each cycle. A single cantilever produces only 1 to 10 milliwatts of power, but you can fit 1000 of them in a square inch—ideal for large data centers and petaflop-scale supercomputers, according to Oak Ridge scientist Scott Hunter.

Walking

Of the calories used to propel a person down the street, fewer than half are dedicated to forward motion.

BIOMECH GENERATORS

+ 20 WATTS PER PERSON

Walking down the street is a terrible waste of energy—so imagine how much power a platoon of marching soldiers squanders. The military will be the first market for biomechanical generators such as Bionic Power's PowerWalk M-Series, a 1.7-pound knee brace that spins built-in gears to run a tiny generator with each stride. A typical human's stride generates 12 watts of energy—and since the brace harvests energy only from the braking portion of the stride, when effort is actually

being expended to slow the leg, tests have shown that it requires no additional energy from the user. Along similar lines, a spring-mounted backpack developed at the University of Pennsylvania collects more than 20 watts from the up-and-down motion of the pack, a figure that varies depending on the weight of the load. (A heavier load results in greater power generation.) For comparison, 3 watts is enough to charge a low-power cellphone in just over an hour, or to continuously power a survival beacon or flashlight.

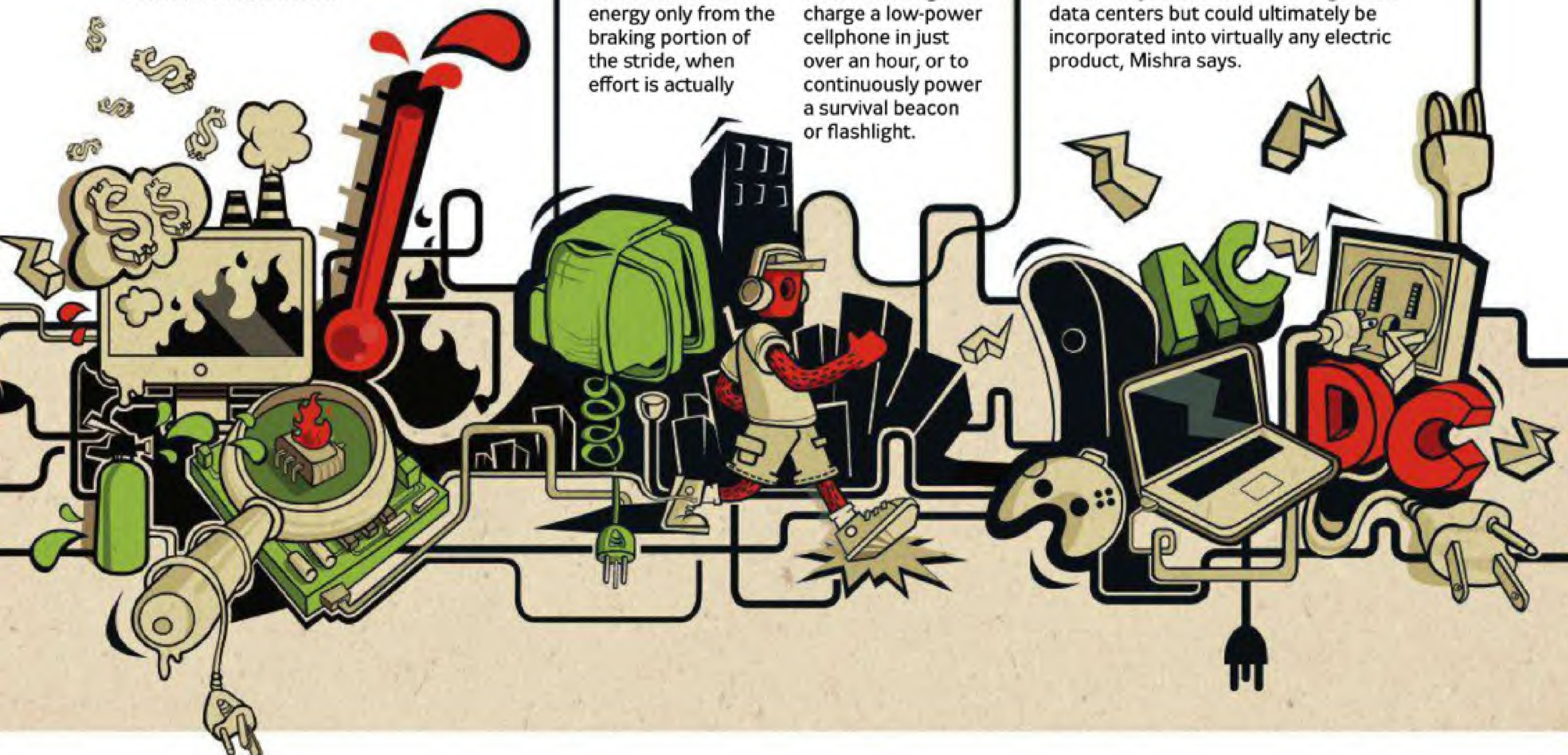
Power Conversion

The fundamental design of our energy grid requires frequent—and loss-prone—AC-to-DC power conversion.

GALLIUM-NITRIDE DIODES

+ 100 WATTS PER PERSON

Every time you plug your cellphone, laptop, HDTV or other electronic device into the wall, you're converting AC power from the grid into electronics-friendly DC power. The reverse happens when DC power from solar panels or wind turbines is converted to AC to feed into the grid. "Power conversion is happening everywhere, in every appliance that uses energy," says Umesh Mishra, CEO and co-founder of Transphorm, a Google-backed startup. "These conversions are very lossy: 10 to 12 percent of electrical energy generated in the U.S. is lost to conversion." The solution, according to Mishra, is to make the diodes and electrodes that help perform this conversion out of a semiconducting material called gallium nitride rather than silicon. Since the atomic structure GaN is capable of holding three to five times the voltage of silicon without leaking, it can reduce waste by 90 percent at each conversion step. Transphorm's converters are already slated for use in large-scale data centers but could ultimately be incorporated into virtually any electric product, Mishra says.



Throwing it away:

Driving

Endemic friction saps energy from the fuel we use to power cars and trucks before it ever reaches the wheels.

Getting it back:

THERMOELECTRICS

+ 350 WATTS PER CAR

Only about 20 percent of the energy contained in your gas tank actually goes to propelling your car forward. The rest is lost as heat through the engine, the drivetrain components and the exhaust. GM, Ford and BMW are all testing prototype thermoelectric systems that generate electricity from the heat gradient between the exhaust and coolant systems, with the goal of improving fuel economy by as much as 5 percent. The biggest challenge to harnessing this wasted energy is

finding a thermoelectric material with high enough efficiency that can also stand up to the rigors of the road for a decade or more. "It's a hostile environment under the hood," acknowledges Dan Coker, president and CEO of Detroit-based Amerigon, the company behind BMW's and Ford's hafnium-zirconium prototypes. In the short term, the most promising avenue for thermoelectrics may be heating and cooling in cars with electric or hybrid drives, Coker says. In fact, Amerigon's thermoelectric seats are already available in 55 major car models.

Motor Operation

A flaw in the design of many electric motors keeps them running at full power, whether they need to or not.

VARIABLE-SPEED DRIVE

+ 100 KILOWATTS PER MOTOR

There are about 300 million industrial electric motors installed around the world. Almost all of them run constantly at full speed and use some form of mechanical damper to regulate output—the equivalent of driving with the gas pedal to the floor while using the brake to control your speed. But it's now possible to use computer-controlled variable-speed drives that match the power output to demand in real time, by adjusting the input voltage and frequency like a light-dimmer switch, says Mark Kenyon of motor manufacturer ABB. Dropping the flow rate of a pump or fan by 20 percent when full capacity isn't needed can reduce power consumption by up to half. Installing variable-speed drives in all the industrial electric motors around the world would save the equivalent power output of 286 nuclear reactors, according to ABB, and the savings would pay for the required capital investment in one to three years. Hearst Tower, which houses the PM offices and was completed in 2006, utilizes variable-speed motors in its elevators and chiller-plant cooling system.

Exhaust Heat

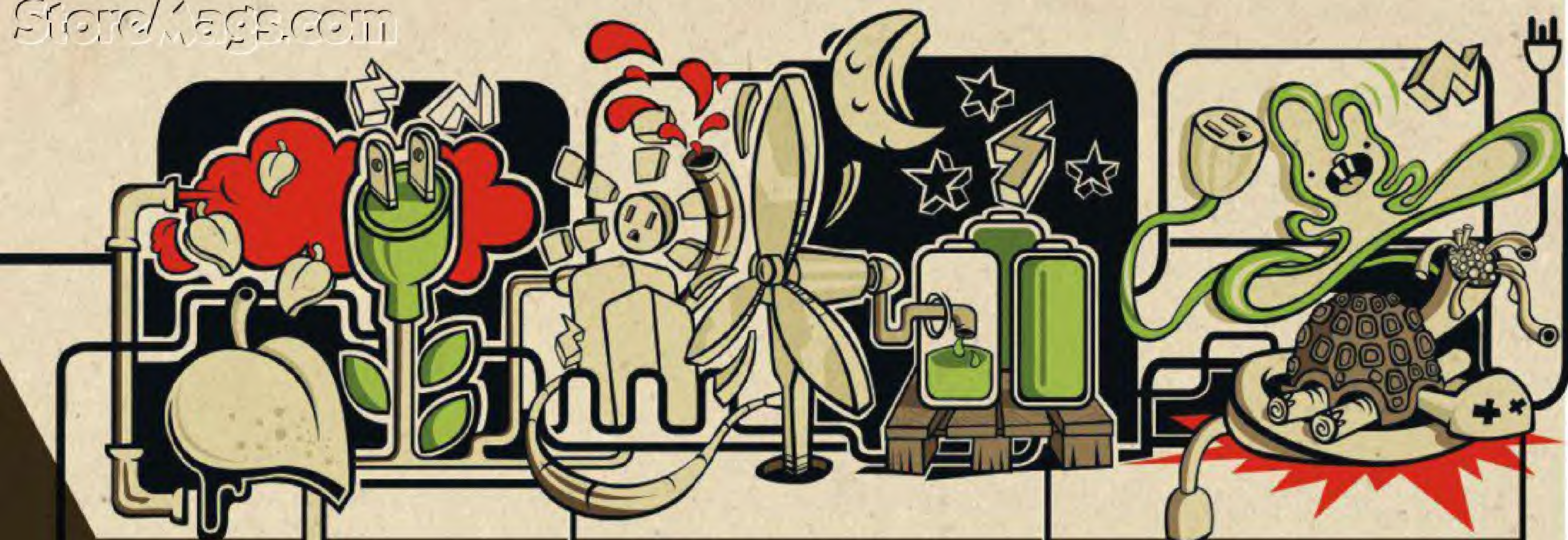
In aggregate, medium-scale industrial equipment produces enormous amounts of difficult-to-collect heat.

WASTE HEAT ENGINE

+ 250 KILOWATTS PER ENGINE

Recapturing waste heat from an enormous power plant is a no-brainer, thanks to the superhigh temperatures and economies of scale. But much more common are small industrial facilities with furnaces, ovens, incinerators and engines, where the amount of waste heat is too small to efficiently power a full-fledged turbine. Florida-based Cyclone Power has developed a versatile Waste Heat Engine that can tap into the exhaust of pretty much any industrial process, using more modest heat from 500 to 1000

degrees Fahrenheit to power reciprocating radial pistons in a Rankine cycle generator. "Our target is much smaller scale distributed power, from about 5 to 500 kilowatts," says Cyclone president Chris Nelson. One of the first uses is actually mobile: running refrigeration and auxiliary power in long-haul trucks, saving 5 to 10 percent on fuel. The company estimates that there are also 10,000 industrial installations in the U.S. that would be suitable for the Waste Heat Engine, which could save 13.5 billion kilowatt-hours a year.



Waste Decomposition

Decomposing matter releases “trash air,” which is both energy-rich and highly polluting, into the atmosphere.

LANDFILL GAS-TO-ENERGY

+ 7.9 MEGAWATTS PER LANDFILL

Food is a highly efficient energy-storage mechanism: a 2-ounce granola bar contains as much energy as a 12-pound lithium battery. Rotting organic matter in landfills releases some of that energy as gas, typically about 50 percent methane, which can be captured, cleaned and burned to generate electricity and heat. Before its 7.9-megawatt EcoLine cogeneration project could start operating, the University of New Hampshire had to build its own gas processing plant to enrich the gas from a nearby landfill. This facility is necessary to remove carbon dioxide, as well as strip out contaminants like sulfur and volatile organic compounds. Nationally, there are 558 landfill gas-to-energy projects operating out of 2400 possible landfills. The EPA has identified another 510 sites as highly promising but untapped, with the potential to produce enough electricity to power 690,000 homes.

Grid Management

Fluctuating demand and steady generation leaves electricity with nowhere to go at night.

GRID STORAGE

+ 20 MEGAWATTS PER STORAGE PLANT

If the wind spins a turbine in the middle of the night, does anyone use the power generated? Not really. Due to steady supply and a drop-off in demand, off-peak power is often much cheaper than peak power, so we need the ability to “time-shift” power by storing it temporarily. It’s not just about night and day: Utilities waste about 1 percent of their total generation capacity balancing out the minute-by-minute fluctuations of supply and demand—waste that can be eliminated by grid-scale storage.

In June, Beacon Power’s flywheel storage plant in Stephentown, N.Y., reached its full 20-megawatt capacity for the first time, using 200 magnetically levitated flywheels spinning at 16,000 rpm. Spain’s Gemasolar concentrated solar array is able to generate power around the clock by storing energy in molten salt tanks. Other promising technologies include giant chemical batteries, compressed-air tanks and water-elevation pumps.

Power Transmission

Outmoded, inefficient copper wiring is both our power infrastructure’s backbone and a major source of waste.

SUPERCONDUCTING CABLE

+ 50 MEGAWATTS PER POWER PLANT

Transmission losses squander about 7 percent of the electricity we generate, and traffic jams on the grid waste billions of dollars a year. Superconducting wire can conduct 100 times the current across supercooled lines as comparable copper cables—with virtually no losses. The problem is that risk-averse utilities are hesitant to embark on massively expensive transmission-line projects with a radically new and unfamiliar technology, according to Jack McCall, American Superconductor’s head of transmission and distribution technologies. American Superconductor installed a short demonstration line on Long Island in 2008, but McCall hopes the use of superconductors to link the country’s three major power grids at the proposed Tres Amigas SuperStation in New Mexico (set to open in 2014) will kick-start greater acceptance of the technology. Meanwhile, South Korea and China are forging ahead with superconducting transmission projects, which should help make the price more competitive with copper.



the

2000 MPH

DREAM

i

It's just another unexceptional small industrial park along the edge of the town of Apple Valley in Southern California's high desert. One cinder-block building is divided into nine 2000-or-so-square-foot work spaces with roll-up garage doors. In one unit, there's a cheerleader academy. In another, a heating and ventilation company. But unit No. 8 is full of aerospace hardware worthy of the Smithsonian. And it all belongs to Waldo Stakes. To Stakes, these parts aren't artifacts; they are the guts of his Sonic Wind Land Speed Research Vehicle, a rocket car he hopes will break the current land speed record of 763.035 mph and believes could potentially go as fast as 2000 mph.

Stakes is 56, but he could pass for a decade younger. He's a fireplug of a guy—tough like Joe Pesci in *Goodfellas*

BY JOHN PEARLEY HUFFMAN

PHOTOGRAPH BY JEFF RIEDEL

Obsessed with speed since childhood, Waldo Stakes spent decades collecting aerospace technology from the mid-20th century to use in his Sonic Wind Land Speed Research Vehicle, a rocket car he's wanted to build all his life—a rocket car he believes is capable of going 2000 mph.

A NEED FOR SPEED

As soon as Karl Benz took his 1886 Patent Motorwagen for its first drive, the race for faster cars was on. Here are eight of the most notable achievements in land speed history.

but without the menace. He's always on the verge of exploding with excitement, as if his own ideas are building up pressure inside him. Engineering terms run together in bursts of explanation and promised performance. He's a full-throttle optimist, certain that there's no challenge he can't overcome. The name Waldo, somehow, fits.

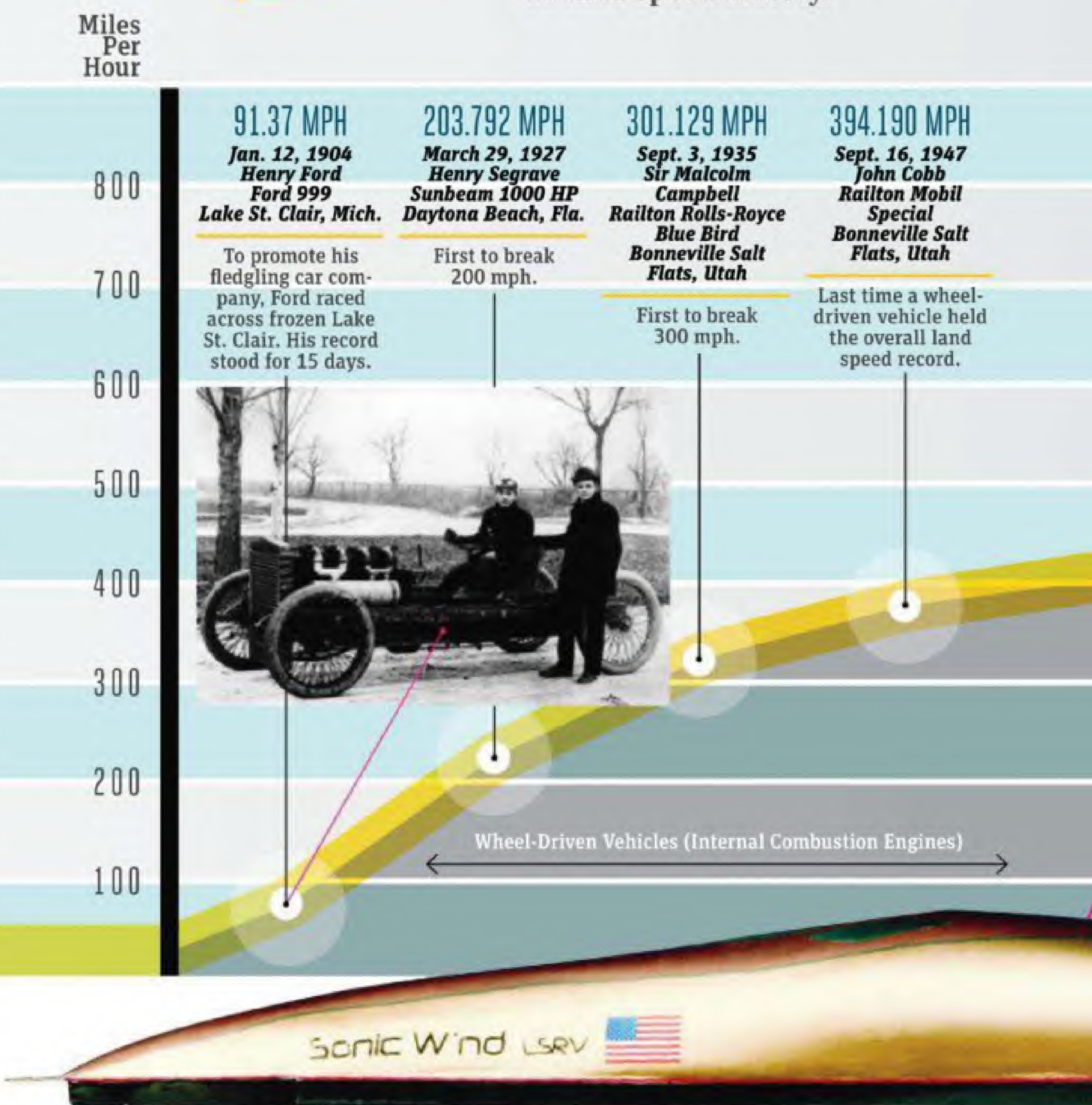
"The Sonic Wind Land Speed Research Vehicle will be the premier land speed car and the most powerful car ever seen on the planet," Stakes claims in his video tour of the project. "Nothing being built in Australia or Great Britain or planned by any nation will be able to touch this car in its velocity. And its stability will be second to none."

Stakes is a general contractor, but his career has never been the priority. In his small office, which overflows with drawings and designs, he reaches for a wooden model about 4 feet long that looks more like a dart than a car. It's the Sonic Wind. Stakes has been dreaming of it nearly his entire life and, since about 2003, spending nearly every waking moment trying to make it a reality.

Stakes's obsession with speed emerged during his knockabout Chicago-area childhood. "When I was 12 years old in 1967, I was eating some Cracker Jack, and the prize was a weirdly shaped little car," he says. "It was John Cobb's Railton Mobil Special—a car that went 394 mph in 1947. I couldn't believe a car could go that fast. By the time I was 14, I was already building model land speed cars and reading everything on missiles and rockets and aerospace that I could."

His formal education ended when he dropped out of Elgin Community College in 1974, but Stakes's passion for speed persisted. "When you study something for 40 years—and I don't mean just think about it, but study something—you can get to be pretty good at it," he says. "I have literally a thousand books on engineering and aerodynamics. Just everything."

Moving his family to Southern California in 1984 to be closer to the aerospace industry, Stakes was soon scouring scrapyards for parts he could use to build a rocket car. His most impressive find is a set of XLR99 rocket engines designed for NASA's legendary X-15, the stub-winged experimental plane that grabbed the flight speed record of 4520 mph in 1967



and has never let go. "Back in the '80s this stuff was considered scrap metal, and everyone was melting it down to recover the silver and gold from the brazed tubing," Stakes says. "But these engines weren't built that way. They're made from Inconel-X [an exotic alloy] and virtually indestructible. I think they cost \$1500 each for four. I have two left. One for the car and a spare."

When it was pushing X-15 pilots such as Neil Armstrong past the boundaries of Earth's atmosphere, the XLR99 delivered up to 57,000 pounds of thrust, burning liquid oxygen and anhydrous ammonia. It's a throttled rocket, capable of operating between 50 and 100 percent thrust. Stakes is contemplating running it on a mix of methanol and liquid oxygen to produce up to 61,000 pounds of thrust.

Stakes also owns and plans to use two

fuel tanks from a Redstone rocket, like the one that carried Alan Shepard into space in 1961, and pressure vessels from the Apollo spacecraft's service module. "This stuff is all well-tested and essentially fail-proof," he says.

Through the years, Stakes has worked on other land speed projects, including a BMW-powered streamliner motorcycle that set several records in the late '80s and an 1160-hp 1988 Ford Thunderbird that captured numerous records for cars with normally aspirated internal combustion engines. But Stakes is enough of a realist to recognize that the bar for admittance into what is now a supersonic club is set exponentially higher. "You can't just toss an old surplus turbojet engine into a homemade chassis anymore and go for it," he notes on a Sonic Wind website managed by his son Tone.



434.022 MPH

Oct. 7, 1964
Art Arfons
Green Monster
Bonneville Salt
Flats, Utah

During the early 1960s, Arfons and Craig Breedlove battled for speed supremacy.

555.483 MPH

Nov. 2, 1965
Craig Breedlove
Spirit of America
Sonic 1
Bonneville Salt
Flats, Utah

Breedlove was the first to set records over 400 mph, 500 mph and 600 mph.

630.388 MPH

Oct. 23, 1970
Gary Gabelich
Blue Flame
Bonneville Salt
Flats, Utah

First record by a rocket-powered car.

763.035 MPH

Oct. 15, 1997
Andy Green
ThrustSSC
Black Rock Desert,
Nev.

The current record holder, Green was the first to break 700 mph, in September 1997. He broke his own record the next month.

Reaction Engines (Jet and Rocket)



Roughly 4 feet long, this is a scale model of the Sonic Wind. If completed, the rocket car will be 47 feet 4 inches long and 7 feet wide.

As Craig Breedlove explained in *POPULAR MECHANICS* while he was unsuccessfully chasing a 750-mph record back in 1965, shock waves, aerodynamic instability, transonic local airflows and other “fatal gremlins” can easily wreck a car at Mach 1 speeds (761.2 mph at sea level). More than 20 engineers are working on a British bid to smash the sound barrier and hit 1000 mph in the Bloodhound SuperSonic car, and even after years of research and \$15 million, they’re not sure what will happen to their vehicle above 800 mph. Stakes believes the Sonic Wind could easily reach these speeds and go well beyond, but he doesn’t even have a computer in his cluttered office.

Nevertheless, he claims to know how to keep the Sonic Wind from wrecking or taking fatal flight at transonic and post-Mach 1 speeds. “The idea is to use all the

forces acting on the car to keep it stable during runs,” he says. “The Sonic Wind’s body changes plane slightly in the nose area. This anchors shock waves over the front wheels to increase the negative lift. These shock waves, along with the shocks that will radiate downward from the rear bi-wedge tail fins, will also be used in roll control.”

At least, that’s the theory. It’s a theory that could use a few years of testing and refinement in an advanced wind tunnel. It’s a theory that a driver may not want to risk his life on.

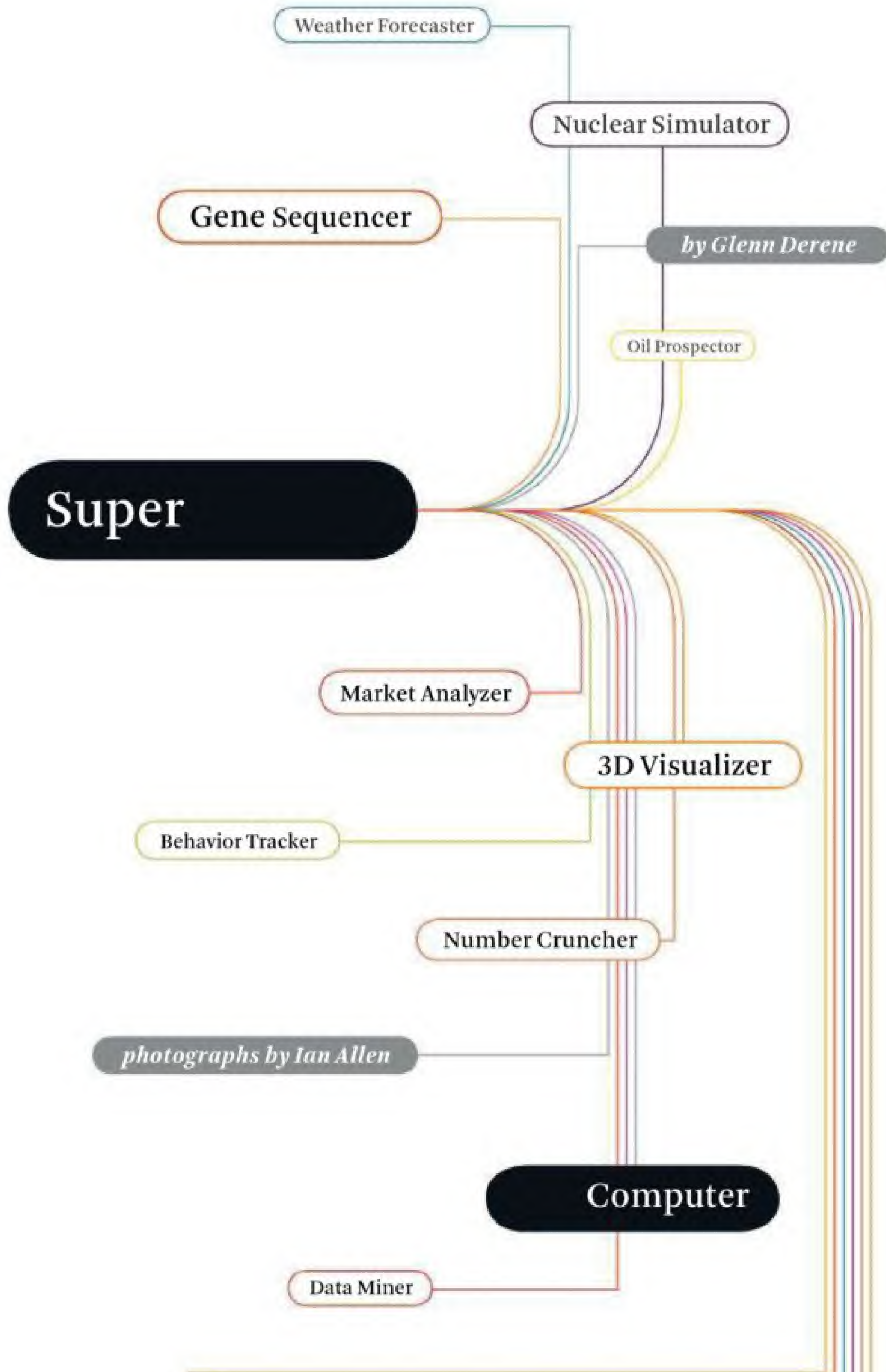
At the moment, the Sonic Wind isn’t much more than its parts laid out where they’d be positioned in what Stakes envisions as a seven-wheeled beast that’s 47 feet 4 inches long and 7 feet wide. Stakes gets help from friends in the land speed community, as well as the occasional moonlighting rocket scientist, but he alone is responsible for the design, handcrafting the scale models and assembling the vehicle.

To any outside observer, Stakes’s chances of completing his rocket car—much less breaking any records with it—might seem vanishingly small. It’s tempting to remind him of the need for wind-tunnel testing, trained engineers—heck, even just a computer. But then, how many of history’s breakthroughs sprang from the passions of similarly obsessed, deeply impractical men—the Wright brothers, Lindbergh, Cousteau... Listening to Stakes spin out his vision of speed, you want to talk some sense to him, make him concede that he’s in over his head. But then you don’t. Does every dreamer need to build the first plane or fly the Atlantic? Is it so wrong to chase a dream that might truly be beyond your grasp?

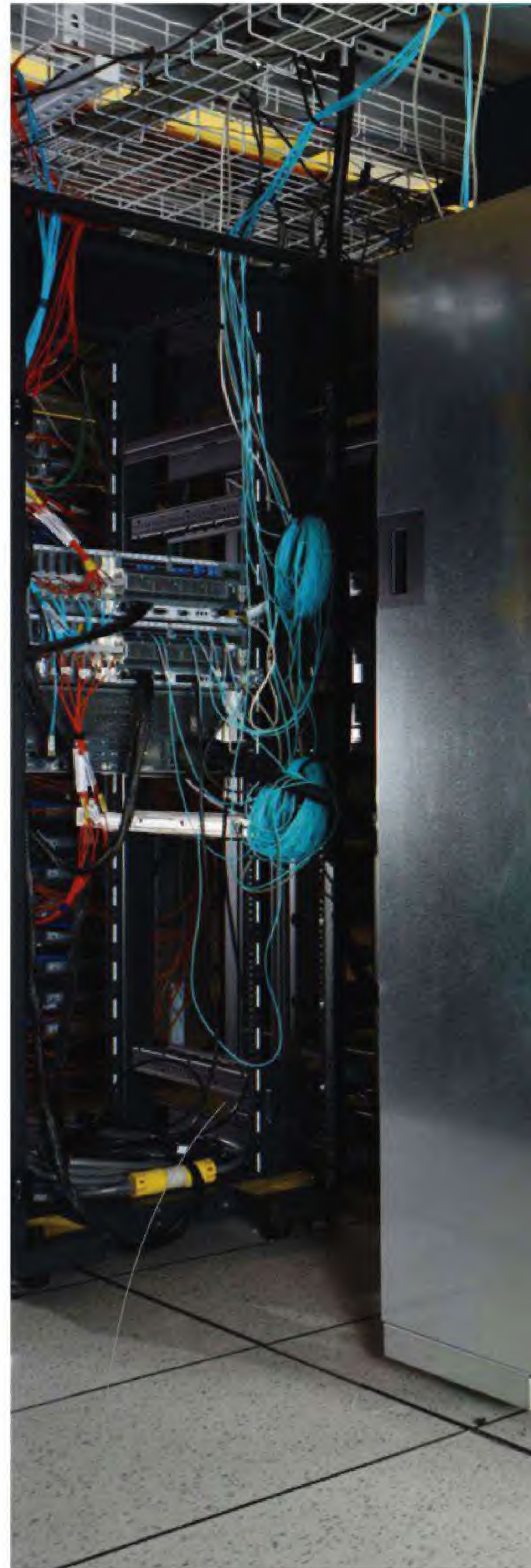
Not long after *POPULAR MECHANICS* visited his tiny workshop, Stakes learned that his landlord was nearly doubling his rent. Undeterred, he simply packed up his parts, plans and prototypes to a small ranch he bought on the outskirts of Apple Valley, deeper in the Mojave Desert. He says he could have handled the rent but actually prefers his new location. It’s isolated, with fewer distractions, and he can work outside. But he won’t be able to walk across the street for lunch at Del Taco anymore. “The best thing about working alone,” he says, “is that you don’t have to ask anyone to make changes.” **PM**

In the September 1965 issue of *POPULAR MECHANICS*, Craig Breedlove wrote about his pursuit of 750 mph and the possible dangers he would face. You can find his original story attached to this one at popularmechanics.com/2000mphcar.





● **CHRIS MARROQUIN IS WAIST-**
 deep in a hole in the floor. He's a tall
 guy with a medium build, but he looks
 awfully short now, and his shirt is pumped
 up to Schwarzenegger size by a 60-degree
 breeze blustering all around him. Grappling
 with a 1-inch-diameter hose, he attempts to
 explain the liquid-cooling system of IBM's
 next-generation supercomputer to me, but I
 can barely hear him over the howling wind.
 We're in a development room of IBM's
 Rochester, Minn., facility, where engineers
 test and assemble the company's Blue
 Gene supercomputers. The air buffeting





• *Fiberoptic networking and power cables intermingle with flexible rubber hoses carrying cooling water to a prototype Blue Gene/Q supercomputer at IBM's Rochester, Minn., facility.*

Anatomy of a Supercomputer

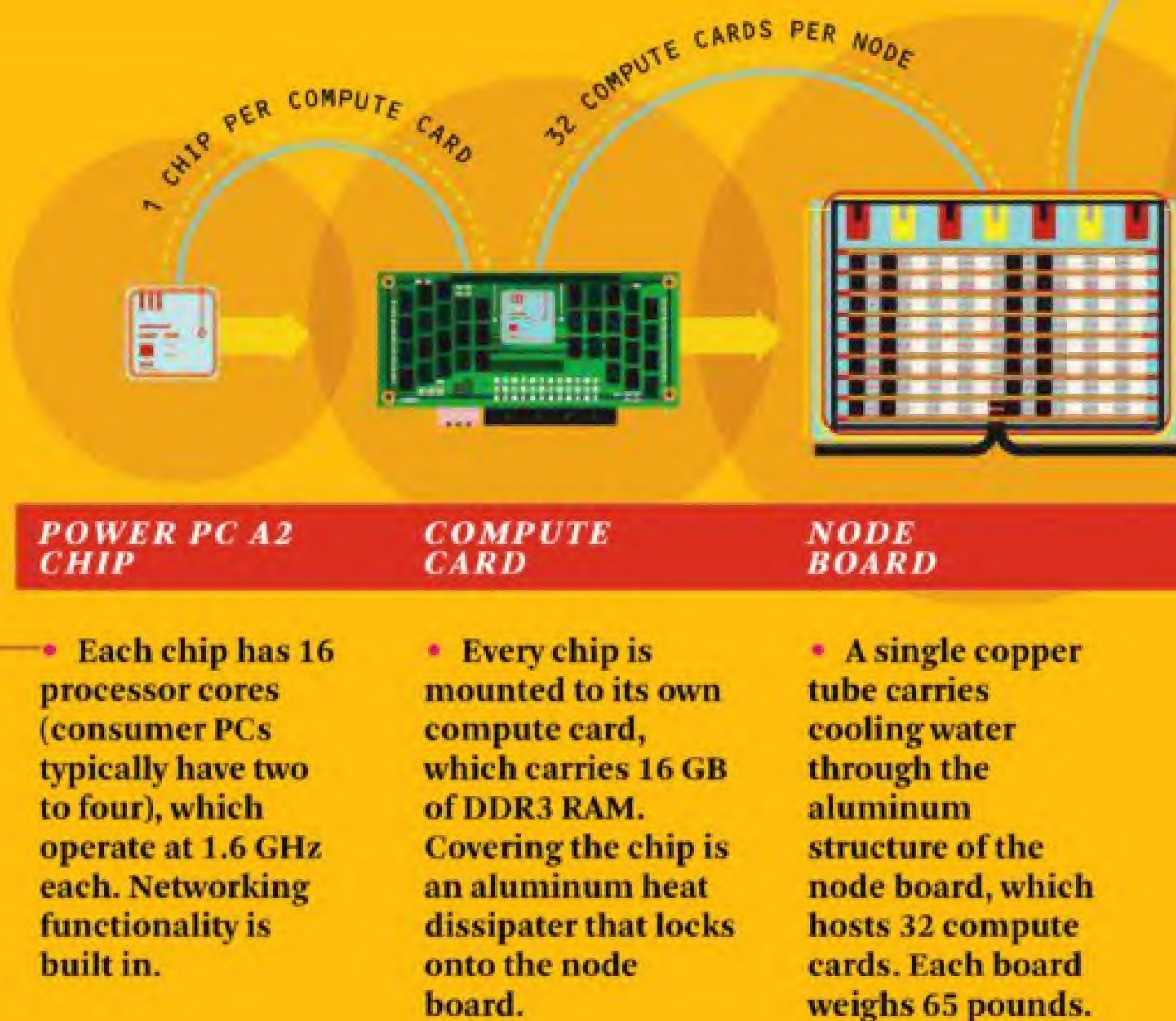
Marroquin cools a small, four-rack Blue Gene/P system capable of 13.9 teraflops per rack, but the hose he's holding is part of a far more advanced cooling system. Filled with deionized water, the anti-corrosive agent benzotriazole and a dose of biocide, the tube feeds into a prototype of the company's new Blue Gene/Q computer. The Blue Gene/Q rack sitting on the raised floor has its own circulatory system—850 feet of copper pipe, with check valves, quick-disconnect rubber hoses and an electronic monitor that measures flow rate, pressure and dew point—designed to shut down if anything goes awry. “You don’t want any drips,” Marroquin says.

As sophisticated as the cooling system is, what launches this machine into the realm of technological superlatives is its processing power: Each rack contains 1024 computer chips, and every one of those chips has 16 processor cores. That's a total of 16,384 processors, making it capable of 209 teraflops, 15 times more power per rack than the Blue Gene/P. Within the next year IBM will ship 96 Blue Gene/Q racks to Bruce Goodwin at Lawrence Livermore National Laboratory (LLNL) in California. Collectively, those racks will become the most powerful computer in the world. It should be able to predict the path of hurricanes, decode gene sequences and analyze the ocean floor to discover oil. But Goodwin primarily wants to use it to blow up a nuclear bomb.

GOODWIN USED TO EXPLODE NUKES THE old-fashioned way. From 1983 to 1991, he designed and oversaw five nuclear weapons tests at the Department of Energy's Nevada Test Site. He and other engineers would dig a 2000-foot-deep hole, toss a warhead and some highly specialized monitoring equipment into a 10-story-tall, 1-million-pound iron canister and lower it into the hole. Then everybody would move way the heck back, cross their fingers and detonate. “Sitting in the control room 10 miles away, it felt like a magnitude 5 or 6 earthquake,” Goodwin says.

All that changed in October 1992, when then President George H.W. Bush declared a moratorium on nuclear testing in anticipation of the Comprehensive Nuclear-Test-Ban Treaty of 1996. After that, if the United States wanted to test any of the warheads in its multithousand-weapon arsenal, it had to do a computer simulation. Thus, our interest in really powerful computers was nationalized.

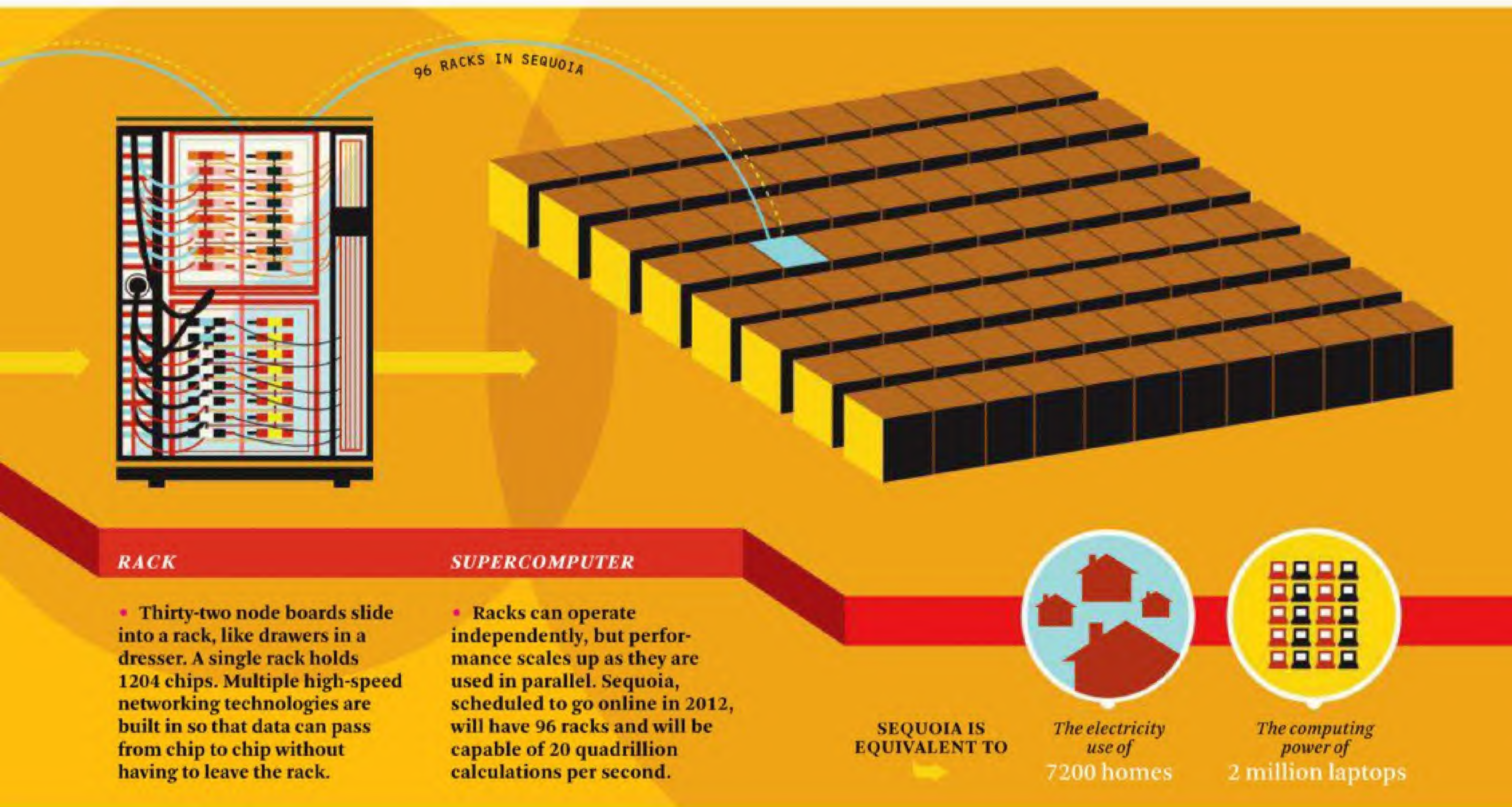
Really powerful computers have been around as long as computers themselves, but the term supercomputer didn't arrive until 1976, when Seymour Cray built the Cray-1. It cost \$8.8 million (\$35 million in today's dollars) and cranked up to 160 megaflops. Yesterday's supercomputer, however, has less power than today's personal



computer—a modern PC has more than 50 times the processing horsepower of the original Cray. In fact, the “super” prefix is so fuzzy that many computer scientists eschew the term supercomputer altogether and call such machines high-performance computers, or HPCs. In an attempt to bring some clarity to the genre, in 1993 a private group called the Top500 project started publishing a twice-yearly list of the 500 most powerful computers in the world. If your computer is on the list, it is by definition a supercomputer.

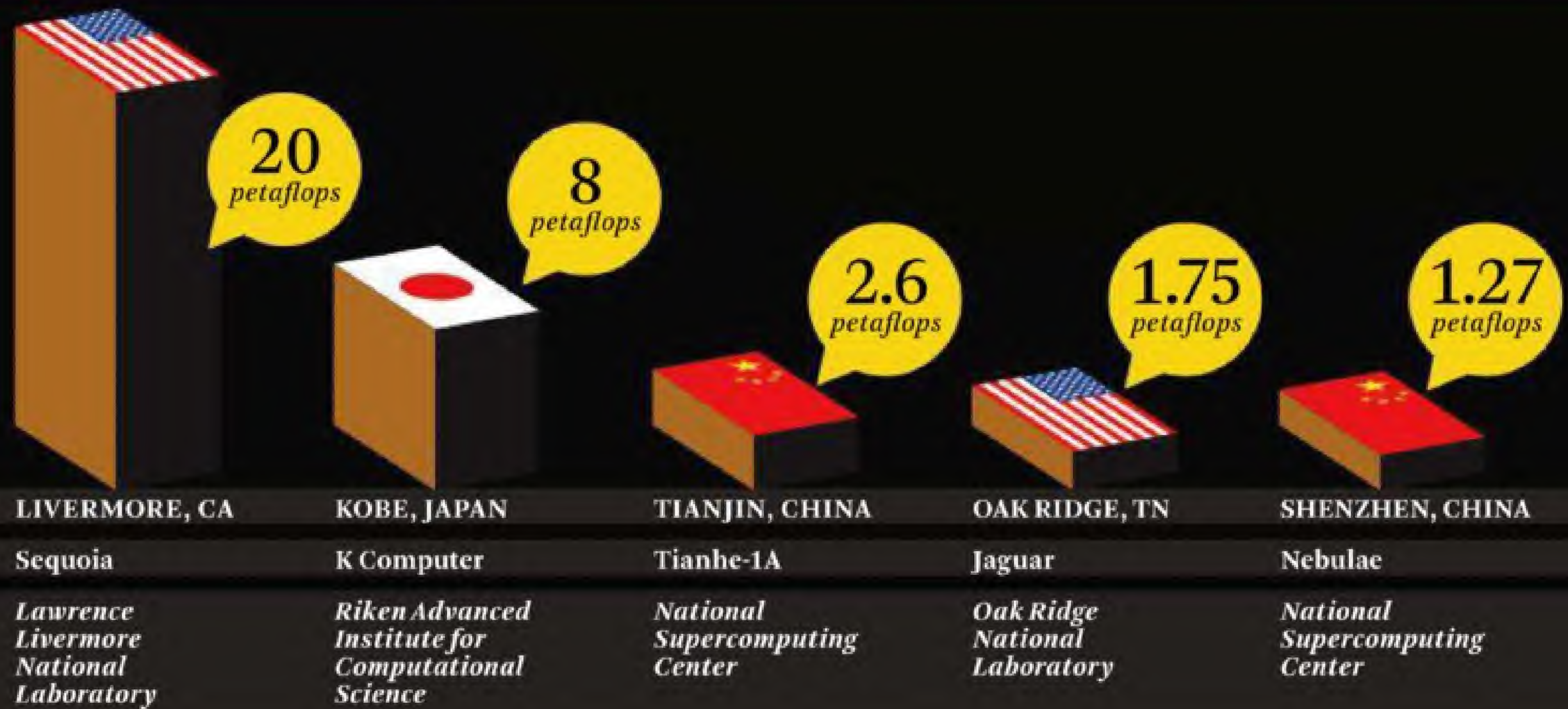
For 17 of the Top500 list's 18 years, the U.S. and Japan have swapped supremacy. But in October 2010, China claimed the top spot with the 2.6-petaflop Tianhe-1A. The computer scientists who design and build these systems tend to work for multinational companies and are cautious about characterizing what they do as a statement of national pride. Regardless, supercomputers have come to symbolize the technological prowess of the countries that build them—a silicon-age version of the space race. In a sign of the whipsaw speed of technological progress, Japan eclipsed China just eight months later, in June 2011, unveiling the 8-petaflop K Computer. The Chinese countered in August, outlining a road map to “exascale” computing, essentially promising a 125-fold increase in computing power within 10 years. If Tianhe-1A was China's Sputnik moment, exascale is its moonshot.

The supercomputer's role in maintaining America's nuclear weapons justifies its status as a national security interest. But China's challenge to the West's computing dominance has led many computer scientists and policy wonks to claim that supercomputing is essential to U.S. economic security as well. These machines are force mul-



Top 5 Super-computer Sites

When Sequoia is fully operational in 2012, it is expected to become the most powerful computer on earth. How does it compare?



tipliers for American scientists, engineers and businesses, the argument goes, and whoever builds the best ones gains an advantage. Supercomputers don't just reflect intellectual and technological power, they also reinforce it.

THE FOLKS AT IBM ROCHESTER BETRAY little interest in China's goal of supercomputing dominance. Their job is to work out the engineering for Blue Gene/Q, and they deliberately focus on the technology, not the politics. They are classic pocket-protector engineers, and their titles are inelegant bureaucratic artifacts that offer little clue to their actual roles. "We're a very small, roll-up-your-sleeves team effort," says Pat Mulligan, development manager for Global Server Integration (who, for the record, had his sleeves rolled up when we spoke). "We're not overly nationalistic, we just

want to make the best computer we can."

The building where Marroquin, Mulligan and the rest of the IBM team are creating the 21st century's most powerful computers is a monument to mid-20th-century corporate futurism. Designed by architect Eero Saarinen (who also designed the St. Louis Gateway Arch), the sprawling structure is clad in dark blue glass. Hallways a half-mile long stretch through the interior. At some point IBM—always pushing the technological envelope—concealed wires in the hallway floors to guide robots that delivered parts and machinery from one assembly room to another. The robots are long gone, a dream of mechanical efficiency undone by reality: They were slow and

CONTINUED ON PAGE 124

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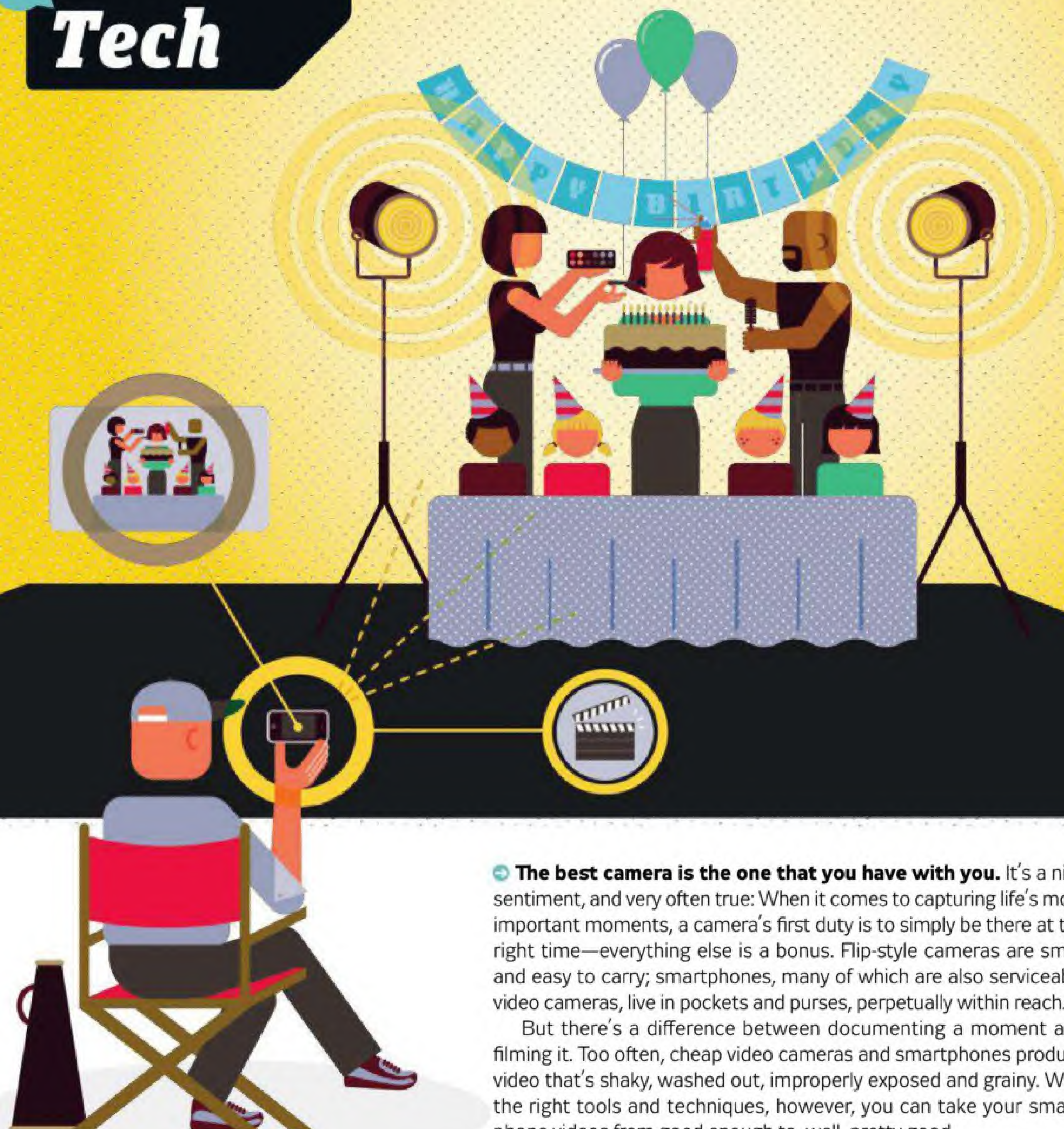
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DIY

Tech

Smartphone
Cinematography

CELLPHONES (AND FLIP-STYLE CAMS) ARE THE NEW CAMCORDERS. HERE'S HOW TO GET GREAT VIDEO OUT OF NOT-SO-GREAT HARDWARE. *BY JOHN HERRMAN*



➡ **The best camera is the one that you have with you.** It's a nice sentiment, and very often true: When it comes to capturing life's most important moments, a camera's first duty is to simply be there at the right time—everything else is a bonus. Flip-style cameras are small and easy to carry; smartphones, many of which are also serviceable video cameras, live in pockets and purses, perpetually within reach.

But there's a difference between documenting a moment and filming it. Too often, cheap video cameras and smartphones produce video that's shaky, washed out, improperly exposed and grainy. With the right tools and techniques, however, you can take your smartphone videos from good enough to, well, pretty good.

INSIDE

×

CLOUD PRINTING + LIFE AUTOMATION + SMART VIDEO APPS

Camera Compromises

➔ **Before you can overcome** your smartphone camera's limitations you need to understand them. How, exactly, are these cameras different from a high-quality, dedicated camcorder? After all, both share the same basics—lens, aperture, sensor and software—and record at either 720p or 1080p. Yet they produce very different video.

The single most important difference between an HD smartphone camera and a more able HD camcorder or digital SLR camera is the image sensor. While midrange camcorders house sensors that measure up to two-thirds of an inch diagonally and typical video-enabled DSLR sensors measure at about 1.1 inches, smartphone sensors tend to be much smaller. (The iPhone 4 utilizes a 0.31-inch sensor for photos and video, and that's on the large side for a phone.) The reason this matters is simple: A sensor's job is to collect light, and it's easier to collect light over a greater surface area. As a result, smaller sensors must be extremely sensitive to light, which reduces color quality, increases image distortion and results in jarring, multicolored speckling, known as image noise.

The second major limiting feature of a cheap camera is its lens. Rather than the generously large zoom lenses found in camcorders and DSLRs, phones and pocket cams have small, fixed optics. Typically these are neither very sharp nor particularly good at letting light reach the sensor; worst of all, they can't zoom (digital zoom doesn't count).

Sensory Tricks

➔ **Marty Martin**, a director and cinematographer from L.A., is accustomed to shooting in professional scenarios with professional-level gear. Yet almost immediately after the launch of Apple's



IMAGE PROBLEMS

SMARTER SMARTPHONE VIDEO

OVEREXPOSURE The sky is white when it should be blue.

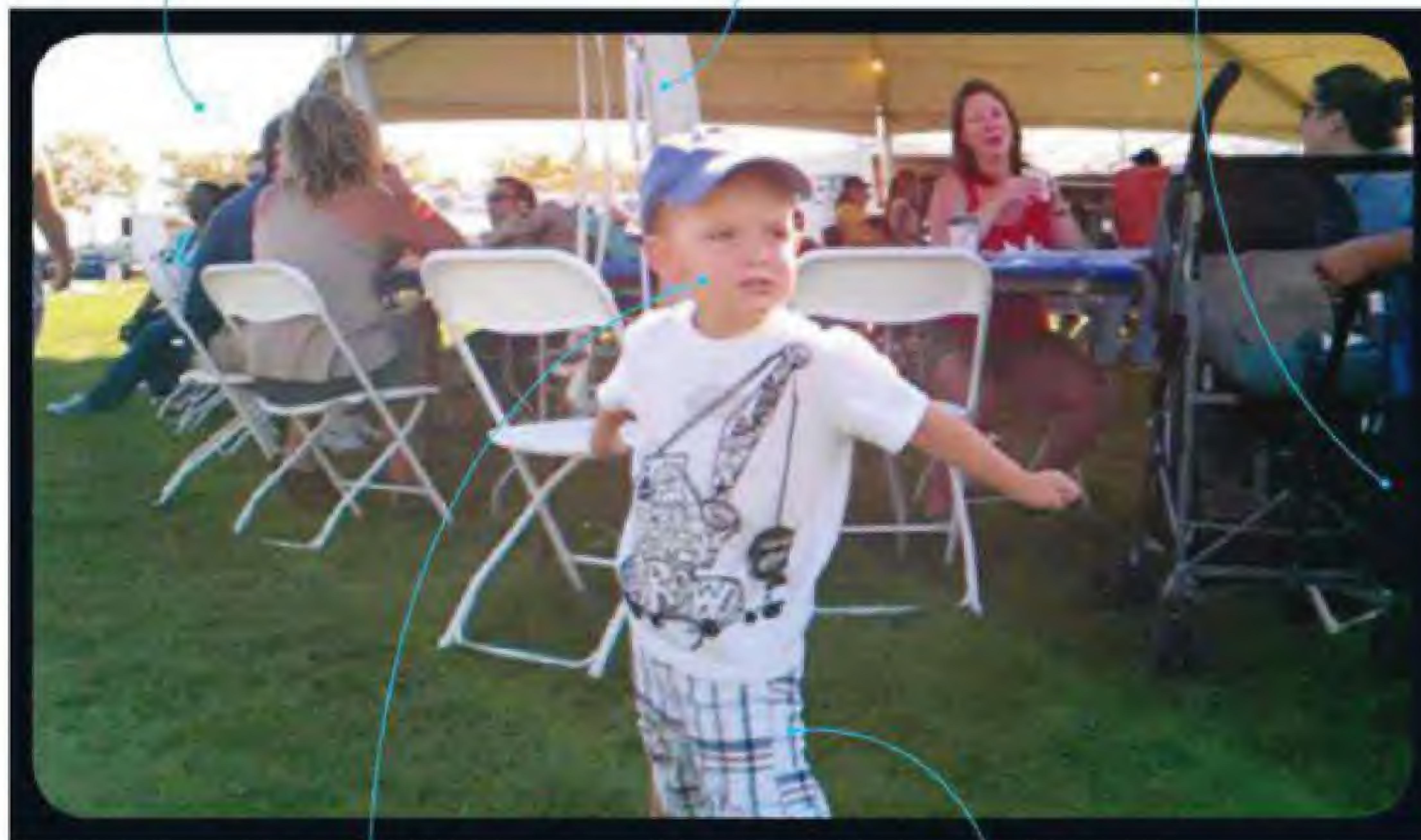
SOLUTION If possible, shoot on an overcast day. If inside, don't aim at a light source.

ROLLING SHUTTER Tent pole appears bent; areas of photo look compressed.

SOLUTION Stabilize the camera, or move it more slowly.

IMAGE NOISE Areas in the shadow are grainy.

SOLUTION Ensure even lighting, or apply noise reduction in an editing program.



COLOR TEMPERATURE

Little boy's skin is strangely tinted.

SOLUTION Ensure multiple light sources are the same color.

POOR FRAMING

He's also awkwardly centered.

SOLUTION Learn and abide by the rule of thirds; move subject to left.

smartphone, he used it to record a music video for his friend Steve Fallows (aka flak-jakt). "Since I first dove into filmmaking I always kept one piece of advice in mind," Martin says. "It's not about the instrument, it's about the person behind it."

The resulting video was impressive, but to Martin the camera's limitations were immediately clear. Above all, he remembers struggling with rolling shutter, a phenomenon that causes a rippling effect in videos. This is because the sensors used in smartphone cameras record by scanning each frame from one side to the other in a sweeping motion, rather than snapping the whole frame at once. If something in the frame is moving quickly—or, more likely, if the whole frame is moving as the result of a shaky camera—the image expands and compresses in conspicuous ways. (Use your smartphone to take a closeup video of a guitar string or a spinning fan for an extreme example of this effect.)

To avoid the rolling-shutter effect, stabilize your camera. If possible keep the camera absolutely still by resting it on a fixed mount. Many flip-style cameras feature tripod mounts, so investment in a cheap miniature tripod or monopod is well worth it. Devices like the Joby GorillaPod double as grips, preventing the vibrations and twitches that are so apparent in freehand-shot videos. Smartphones lack tripod mounts, but cases can be purchased to add ¼-inch screw mounts to many common models. (The following page offers some DIY alternatives.) For his friend's music video, Martin took stabilization to the extreme. "I really limited the range of movement," he says, which was key to the success of his video: The majority of the footage was shot from a static mount, which rendered the rolling-shutter effect unnoticeable—and gave



A CELEBRATION OF AMAZING CREATIONS
AND THE PARTS THAT MADE THEM POSSIBLE.

ILLUMINATE YOUR ARTWORK!

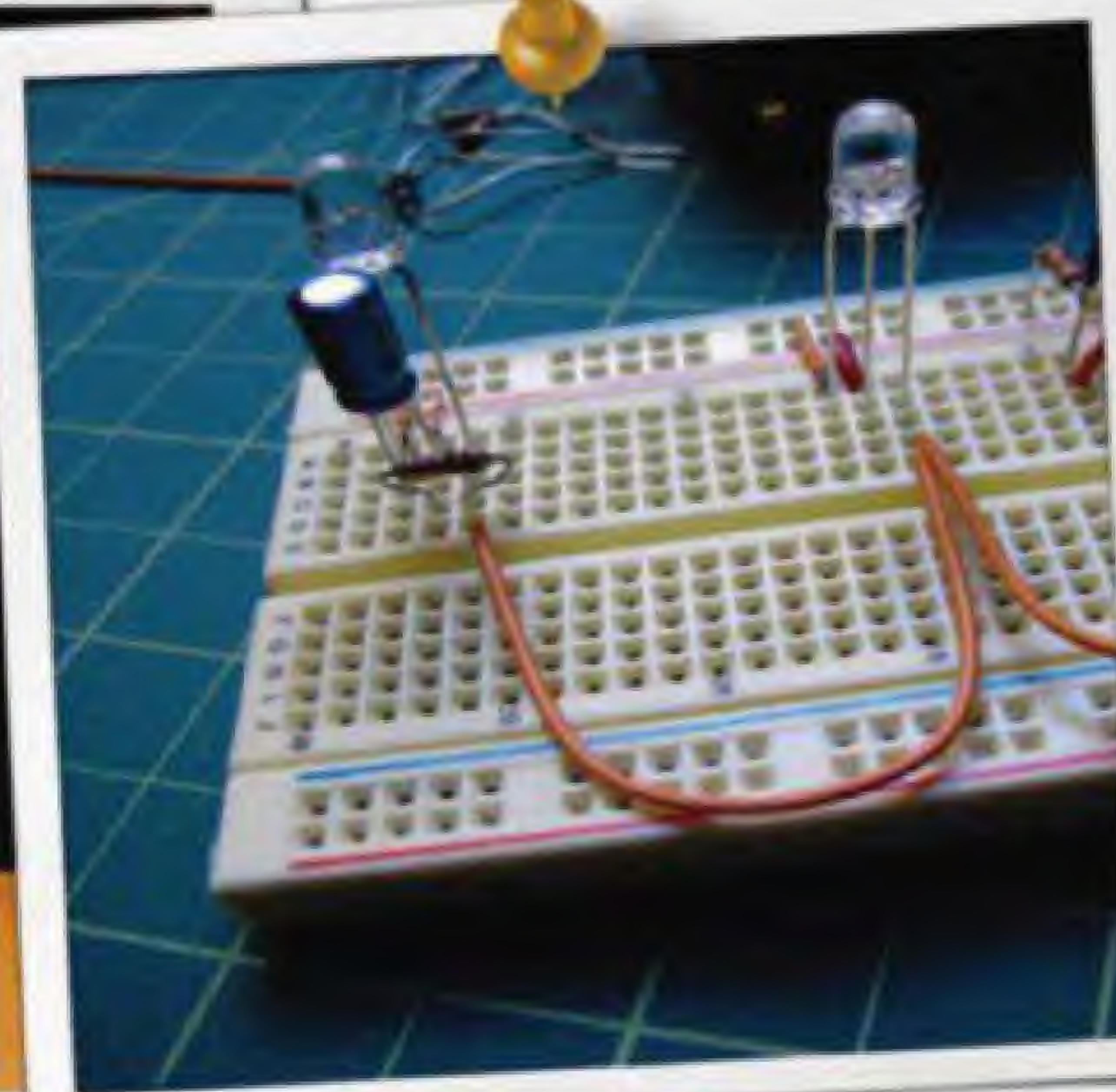
Make a Modern Mood Lamp with Light-Emitting Diodes.

LEDs (light-emitting diodes) have endless uses, both practical and creative. When they were first available, you could get them in any color—as long as it was red. These days, they come in a range of colors. They also use tiny amounts of electricity and emit almost no heat, so they're a safer way to light up your artistic project.

LEDs squeezed into one little package. Usually, these "RGB" LEDs require some sort of external microcontroller (a tiny computer-on-a-chip, such as a BASIC Stamp or Arduino) to control the changing colors. RadioShack, however, makes a special LED with the color-changing circuitry built right into the package.



My Artwork



After a bit of experimentation, I came up with a circuit that causes the LED to reset after each cycle, so that it endlessly loops through patterns of color.

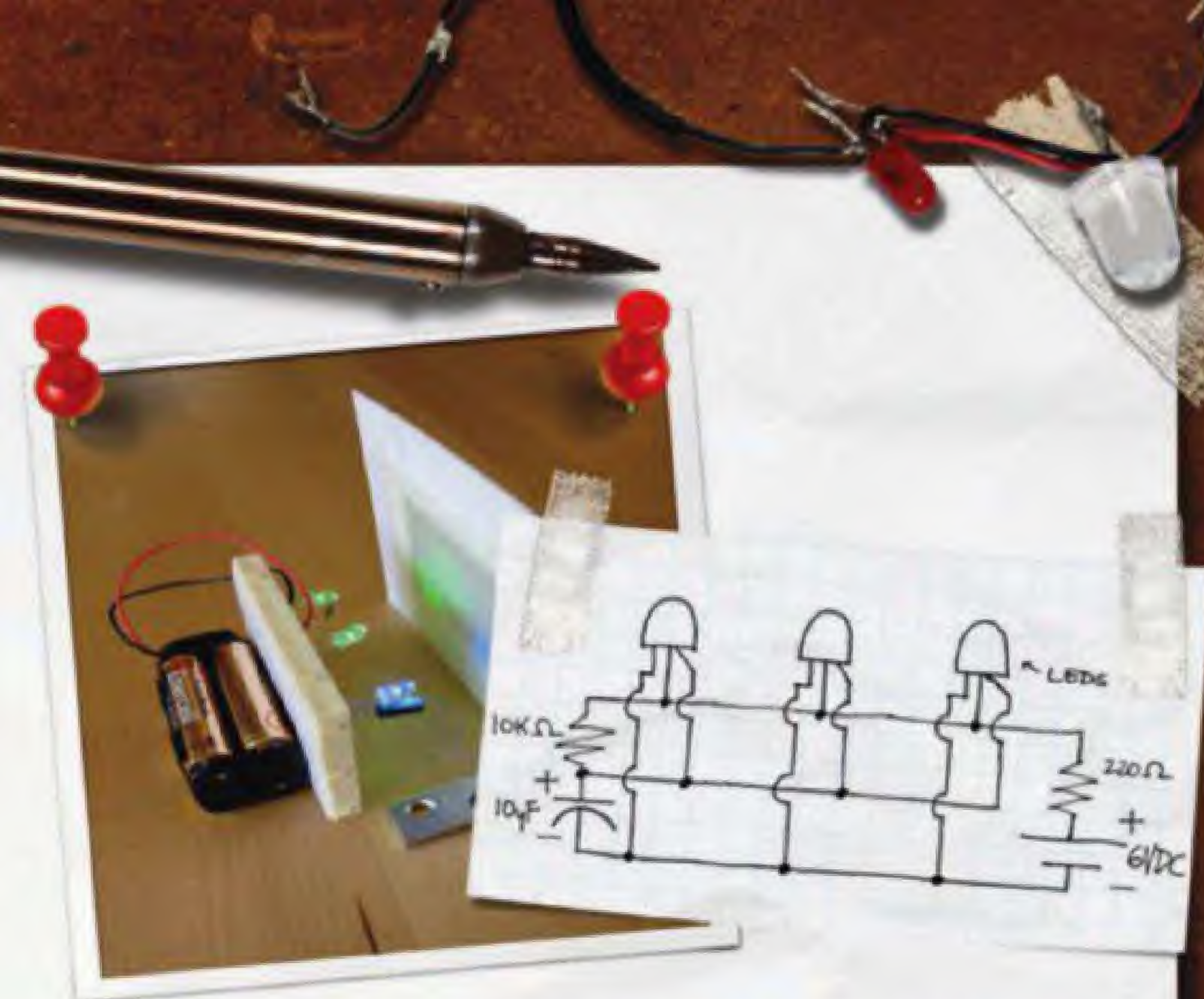
To create your own unique piece of luminescent art, follow the circuit diagram, inserting the components into the breadboard socket as shown. Note how the LED leads in the diagram match the angle of the leads on the LEDs themselves—it's

important to hook these up correctly! The polarity must be correct for the capacitor as well. Use the 9V snap connector to connect the 4 "AA" battery holder to the board, but make sure you never attach a 9V battery! This circuit is designed for six volts, so a 9V battery will damage the LEDs. With everything plugged in, your LEDs should start to cycle through an array of colors.

Here is an easy-to-make piece of illuminated art that adds a moody, ambient glow to any room. It uses multicolored LEDs to project abstract, shifting patterns of colorful light onto a translucent, framed screen.

To produce the varying colors, you'll want a special LED that actually has separate red, green and blue

For the frame, you can have your local frame shop cut a small piece of mat board to about 5"x4", with a 3"x2" window. For the screen, you can use a piece of heavy paper velum (available at most art stores). Cut the



velum to about 3"x4" and tape it to the back of the mat board so that it completely covers the window.

The LEDs need to project horizontally at the screen, so you can bend the leads or make the entire breadboard stand on its edge by peeling some of the protective paper off the adhesive backing and sticking it to the battery case. You can make the frame stand upright by attaching a small angle bracket with some double-sided tape.

Experiment with the position of the screen relative to the LEDs, as well as the positions of the LEDs themselves, to get the coolest possible pattern! You can also experiment by putting different materials between the LEDs and the screen to distort the light in interesting ways, like drizzling a bit of hot glue on the LEDs (be careful!) to create shimmering psychedelic blobs of light!

By Ken Murphy

Want to see it in action? This project is featured in one of our online videos at radioshackdiy.com.

PARTS

- ☐ High-Brightness 7-Color 5mm Blinking LEDs
- ☐ 4 "AA" Batteries
- ☐ 9V Battery Snap Connector
- ☐ Modular Breadboard Socket

MOOD LAMP FEATURES THESE RadioShack PARTS:



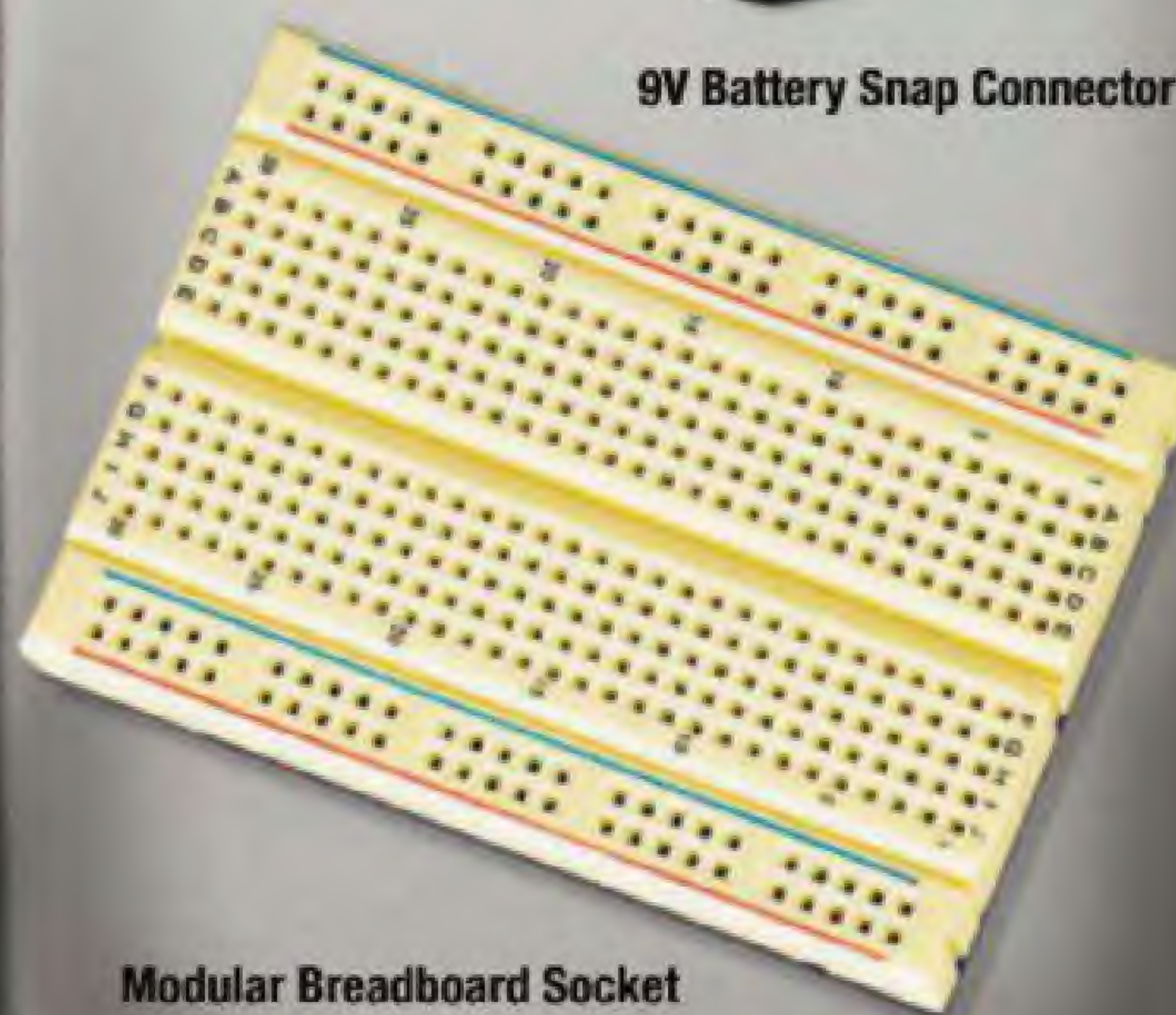
High-Brightness 7-Color
5mm Blinking LEDs



4 "AA" Batteries



9V Battery Snap Connector



Modular Breadboard Socket

To submit your own creation, explore other great creations and get the hard-to-find parts you need, visit RadioShack.com/DIY



SCAN THIS QR CODE TO LEARN
MORE ABOUT THIS PROJECT



the impression that the video was shot with a much better camera.

If you absolutely must shoot free-hand, and without any kind of stabilizing accessory, there are a few rules to follow. Hold the camera with both hands and grip it firmly—a tentative touch inevitably results in shakiness. Move slowly, turning the camera with your whole body rather than your wrists; fast movements don't translate well with almost any camera, but cheap ones amplify the problems. Lastly, if you're using a smartphone, turn the handset sideways. It will be easier to hold steady and ensure that your video is shot in the correct aspect. A video can look only so good with giant black bars on either side.

Indecent Exposure

➔ **Cheap lenses and straining** sensors make getting an even exposure on a low-end camera difficult. Smartphones' highly automatic shooting modes mean that it's often easier to control your environment than it is to control your camera settings.

Shooting outside is best done on a cloudy day or in the shade. Cheap camera sensors have a low dynamic range, which means that they are unable to record drastic variations in light in a single frame. Too much light will overwhelm the camera, with bright skies or reflections causing the rest of the frame to be underexposed. If the glaring sun is unavoidable, shoot from an elevated vantage. This will ensure that the sky is mostly out of the frame and allow the camera to meter your subject, not the sky, for its exposure.

Shooting indoors affords you more control, but introduces new problems. Don't light your subject from behind or from directly in front; use diffuse lighting (a lampshade) where possible, or light from the sides. In any case, make sure there's enough illumination—cheap cameras perform poorly in low light. A humble shop light bounced off a ceiling or wall, for example, can turn a shadowy scene into a tastefully lit one.

You'll also need to account for light

color. Cameras automatically adjust to compensate for the color, or temperature, of a light source—natural light is very cool, while many household lights are very warm. An open window near a shining lamp may leave your subject with a yellow or blue tint, depending on which light source the camera focuses on.

The Basic Rules

➔ **Some rules apply** to all camera types. Pay attention to how you frame your subject, and don't always go for the obvious shot. Respecting the rule of thirds, which divides a frame into a 3 x 3 grid, will help you compose more interesting shots. Try placing your subject somewhere other than the center of the frame.

Anticipate your subjects' actions and give them space to move; likewise, if someone is facing to the left or right, move him to the opposite side of the frame. If you can't fit a subject's entire body in a shot, crop at a natural cutoff line, such as the elbows, knees or hips. For further stylistic guidance, Martin recommends an impromptu apprenticeship with the many talented videographers who post work online: "Do some research on Vimeo [a community for original video]. Look up beautiful home videos of subjects you like, and spend a few minutes figuring out what makes them good."

Video editing has become extremely simple with the advent of user-friendly editors like iMovie and Windows Live Movie Maker and can help polish a decent video, or salvage a bad one. Your first impulse when shooting with a smartphone may be to record snippets and avoid editing altogether. You're always better off overshooting and cutting later. You have gigabytes of space to record with, and besides, the only way to make sure you don't miss the pivotal moment of your kid's soccer game is to keep the camera rolling. Editing out a fumble or a face-plant takes just a few seconds, but you can't edit in something you didn't film.

PM



CAMERA BAG DIY

BUILD YOUR OWN ACCESSORIES

Using a smartphone as your primary video camera isn't solely about convenience—it's about saving money by getting the most out of a gadget you already own. Here are three ways to save money on accessories, too.



The 20-Cent Mount

Smartphones don't have tripod mounts, but making one is easy. Cut a paper or Styrofoam cup in half, then cut two phone-size slots in the bottom half. Punch the tripod's mounting bolt through the bottom of the cup, then tighten a nut over the washer.



The String Loop

Keeping a smartphone stable and vibration-free is close to impossible without some help. A loop made from 10 feet of string or twine wrapped once around your phone's body lets you stabilize your shots against tension provided by your foot.



The Handi-Clamp Grip

For a more mobile stabilization option, a cheap, rubber-padded hand clamp can serve as a secure grip for a smartphone. Clamp with care—too much pressure can damage the screen. Best used in conjunction with a sturdy case.

Digital Clinic

by John Herrman

Q+A



Google Cloud Print makes your printer available to nearly any gadget, from nearly any location.

Q Cloud Printing

My printer predates my computers, phone and especially my tablet, but it still prints just fine. How can I get this old thing to play nice with my fleet of wireless gadgets?

A The good news is that you aren't missing much. In an industry defined by reinvention and obsolescence, printing technology has stood relatively still. Printers are usually replaced when they break, not because something better has come along—a rarity in the electronics world.

Characteristically, printers have been slow to adapt to the rise of wireless gadgets. The newest Wi-Fi printers come with tools for connecting with mobile devices, but these don't work with other brands of printers. For those of us with a slightly older vintage of inkjet, there's Google Cloud Print.

Cloud Print lets you add any working printer to your Google account, where it can be accessed over the Internet without the need for special drivers or complicated software. It enables printing from Android and iOS devices, not to mention any PC or Mac, over a Web interface (and with apps). You can even share your printer with people in different locations or send items to your home printer while

you're on the road—although you'll have to leave your home computer on.

Here's how to set it up: On the computer that's connected to your printer, install the Google Chrome Web browser (google.com/chrome). Once Chrome is installed and running, click on the Settings menu in the upper-right-hand side of the window, represented by a crescent wrench icon. Select Options (or Preferences on a Mac), which will take you to a settings dashboard. In the Under the Hood section, select Sign In to Google Cloud Print, enter your Google account username and password (if you don't have one, you'll need to sign up) and any printer connected to your machine will be instantly added to your Google account.

There are a handful of ways to send documents through Cloud Print. Your printer will now show up in both the desktop and mobile versions of Google Docs, from which you can print documents you have created on or uploaded to Google's site. Documents stored on Android devices can be printed using a free Cloud Print app and from iOS devices using PrintCentral Pro. In addition, from your Cloud Print dashboard (google.com/cloudprint), you can share your printer via email. Relatives, for example, are then able to send photos directly to your printer, whether they live across town or across the country.

An Internet Butler I'm so inundated with emails, messages and notifications that I'm starting to miss stuff. Is there any way to set special alarms—like a text message or a call—for, say, important emails?

I'm always hesitant to recommend solving a noise problem with yet another layer of noise, but there *is* a way to do

PHOTOGRAPH BY DEVON JARVIS

GANDER MTN., SCHEELS, SPORTSMAN'S WAREHOUSE, CABELA'S

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OUTDOOR

this. A new site called If This Then That (ifttt.com) lets you set triggers for specific events online, and then assign personalized actions to follow them. In your case, you could set a trigger for emails from an important email address—let's say a parent's. You would then be asked to set an action to signal a new email. In your case this would be a text message to your phone.

Yours is a simple case, but IFTTT is capable of much more complex notifications, with connections to dozens of major web-sites. It plugs into Facebook, Twitter, Craigslist, LinkedIn and plenty of other social networks, as well as a bevy of sites like Flickr, YouTube, Google and Dropbox. It can also monitor stock prices and weather. You can set IFTTT to scour Craigslist for a desired item so that you get an email when it's listed. You can get a call every time rain is forecast for the next day. You can have Facebook photos tagged with your name automatically backed up to a site such as Dropbox or Flickr. You can set text reminders for important dates or even get a daily wake-up call.

IFTTT users have posted hundreds of combinations, or "recipes," to help you get started building your own.

Don't Convert That Video

I've got hundreds of videos stored on my computer, but only a small portion play on my phone and iPod. Do I really have to convert them all?

For all their talents, smartphones are pretty bad at playing video. They natively support an extremely narrow range of video types, and unlike computers, phones don't allow users to install the system-level software needed to decode other video formats. If your video

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MOTIVATION

THE GAME OF LIFE

It's a trick businesses have used for years: If you want people to stick with something, make it feel like a game. That's the thinking behind points-driven rewards programs, loyalty schemes and referral systems. A new breed of apps and websites lets you use this trick on yourself, turning mundane—but necessary—tasks into games.

FITOCRACY



THE TASK
Exercise

THE MOTIVATION
Points, badges, direct competition, peer pressure

DOES IT WORK?
Quantifying workouts in points is oddly addicting, even if they ultimately mean nothing.

MINT



THE TASK
Personal finance

THE MOTIVATION
Financial-fitness scores, a goal-tracking system

DOES IT WORK?
Imagine progress bars for major financial goals. They're counterproductive if they're not moving.

RIBBON HERO



THE TASK
Microsoft Office

THE MOTIVATION
Skill levels, instructive task challenges

DOES IT WORK?
An instructional manual disguised as a game. Great for learning Office; distracting if you have work to do.

GREENOPOLIS



THE TASK
Recycling

THE MOTIVATION
Points, redeemable for vouchers and coupons

DOES IT WORK?
Well, how frugal are you? You can expect plenty of twofer dinners and cheap movie tickets if you stick with it.

isn't encoded in H.264 format, chances are you won't be able to play it on your device's default video player. So you'll need to get another one.

For Android users, the free MoboPlayer app is a must-download. This app will play any video your computer can. And file transfer is easy—just connect your Android device to your computer and drag and drop the video you want to watch.

The situation is less hospitable for iOS users. Of the various video apps for the iPhone, iPod Touch and iPad, the most versatile option is an app called Azul, which costs \$2. Like MoboPlayer, Azul will play nearly any video you can throw at it, but unlike with MoboPlayer, adding videos to your device with Azul requires a bit of work on your part. Since iTunes permits only the syncing of compatible video formats, Azul requires videos to be added via the File Sharing menu in iTunes, under the Apps tab.

There are some downsides to using third-party video players. Android and iOS tap into special decoding hardware found in phones, tablets and media players to play H.264 videos. Other video formats can't use this decoder chip, leaving playback to the device's main processor, which, while it's likely powerful enough to play most videos, might choke on high-quality HD files. And even if MoboPlayer or Azul is able to play a video without shuttering or pausing, doing so will be a serious strain on your device's processor and, by extension, your battery. I've lost a fifth of a battery charge to one half-hour TV episode, but that may well be a sacrifice worth making.

PM

Got a technology problem?

Ask John about it. Send your questions to pmdigitalclinic@hearst.com. While we cannot answer questions individually, problems of general interest will be discussed in the column.



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Drill Team

THE LATEST 12-VOLT DRILLS LIGHTEN YOUR WORKLOAD—AND YOUR TOOLBOX.

BY ROY BERENDSOHN

➔ **Compact and spunky**, the 12-volt drill can often stand in for one twice its size. Consumers love the tool's light weight and versatility, and manufacturers have piled into the category. We recently tested 13 brands, driving 2134 2½-inch screws into pressure-treated lumber and boring 2193 ½-inch holes into 1 x 8 boards. Whether driving or drilling, we ran the battery from full to dead. In general, we found that 12-volts offer great performance and value, mainly because of improved lithium-ion-battery technology, and regardless of price. In fact, any one of these tools would make a great gift. Here's a baker's dozen to choose from.

INSIDE ✕ ROLLING PAINT THE ULTIMATE CHRISTMAS STOCKING

BLACK & DECKER LDX112C

Price: \$50
½-in. holes: 192
2½-in. screws: 176

This lightweight drill (2.4 pounds) is perfect for storing in the kitchen drawer—and for fixing it, too. Its drilling and driving performance was perfectly respectable, even better than that of pro models if you consider just the number of screws or holes, not the speed. We also liked the bottom-mount battery design, which allows the tool to stand upright and makes for a slim handle.

Dislikes: Has only one speed and one battery. An extra battery will cost you \$40.

BOSCH PS31-2A

Price: \$156
½-in. holes: 118
2½-in. screws: 153

This is a great little drill, offering almost full-size speed and torque in a small package. It's well-encased with rubber overmold, making it less likely to slip from your hand but capable of surviving a bounce off the floor in case you do fumble it.

Dislikes: The Bosch's clutch surface is small and annoyingly slippery. New products entering the category are catching up to and surpassing this once formidable tool.

CHICAGO ELECTRIC 68126

Price: \$50
½-in. holes: 216
2½-in. screws: 200

Here's a tool that costs less than a bag of groceries but can drill more holes and drive more screws than its pro-quality competitors. If you drive a lot of small screws, it's hard to beat this budget-friendly tool.

Dislikes: It has just one battery and no charger. An extra battery costs \$20 and the charger, \$15.



RATING ●●●●●



RATING ●●●●●



RATING ●●●●●



RATING ●●●●●



RATING ●●●●●



RATING ●●●●●

CRAFTSMAN NEXTEC 00911812000

Price: \$80
½-in. holes: 192
2½-in. screws: 180

The Craftsman's drilling and driving numbers attest to the fact that this is a small but capable tool. We also liked the crisp action of its clutch ring, user-friendly forward-reverse switch and sliding two-speed selector switch.

Dislikes: Only one battery.

DEWALT DCD710S2

Price: \$160
½-in. holes: 196
2½-in. screws: 171

This was one of three tools that flew through both the drilling and driving tests (along with the Milwaukee and the Ridgid). For example, it bored 196 holes in about 5 minutes—a rate of one hole every 1.5 seconds. Other drills bored more holes or drove more screws, but it took them three times as long.

With a second battery at the ready, the DeWalt has plenty of backup capacity.

Dislikes: The battery attachment had a fair amount of play. This didn't affect the drill's performance, but we prefer a more solid mount.

HITACHI DS10DFL

Price: \$100
½-in. holes: 172
2½-in. screws: 197

The Hitachi is ideal for installers, technicians or

KNOW YOUR STUFF

Slotted and Phillips dominate the fastener-head world, but myriad other shapes facilitate a turn of the screw. Use this guide to increase your hardware smarts.



Clutch



One-way



Phillips



Pozidriv



Robertson



Slotted



Spanner



Spline



Torq-set



Torx



Torx, tamper-resistant



Pentalobe

DIY **Home** 12-VOLT-DRILL TEST

computer modders who need a small, nimble drill. Its 195 inch-pounds of torque are more than ample for driving small machine screws and assembling electronics. Its light weight (2.2 pounds) and slim motor housing also make the drill ideal for these applications, and the bottom-mount battery keeps the tool standing at the ready. **Dislikes:** The Hitachi needs a single-sleeve clutch, and its two-speed selector switch is very stiff.

MAKITA
FD02W

Price: \$144
½-in. holes: 128
2½-in. screws: 116

Makita is all about the details. Packed in a rugged plastic case, this was the only drill to come with a belt-mount holster that looks like it could pack a 9-mm, a pair of batteries and a charger. If I were a telecom guy, going up and down a ladder all day and dragging tools in and out of my van, I'd probably buy this. While it was outdriven by larger and heavier drills in the test, the smooth, quiet operation made it an admirable workhorse. **Dislikes:** The battery mount is kind of clumsy and stiff.

MILWAUKEE
M12 2410-22

Price: \$150
½-in. holes: 161
2½-in. screws: 171

A large percentage of Milwaukee's customers are plumbers and electricians, people who drill and drive for a living. That accounts for the tool's robust construction, which is why we like it so much.

If you really pound on a drill, even a small one like this, it's the right tool for you. **Dislikes:** The battery could use a better grip surface. It's a bit slippery.

PORTER CABLE
PCL120DDC-2

Price: \$90
½-in. holes: 166
2½-in. screws: 164

We liked this tool's textured grip surfaces, balance and decent power and speed. What else could you ask from a drill? Well, how about a motor casing with a handy, magnetic bit holder? The Porter Cable has one of those. **Dislikes:** Nothing noted.

RIDGID
R92009

Price: \$140
½-in. holes: 177
2½-in. screws: 167

The Ridgid's 300-inch-pound torque rating helps it twist through holes using a spade bit or spin in a big bunch of screws—in seconds. Its chuck ring turns with a crisp, easy action, and the microtexture rubber overmold grip sticks the tool to your hand like flypaper. The Ridgid's battery proved to be the best of the bunch—there's not a single exposed electrical contact surface to be found on it. Also, the battery has a slick, glass-filled nylon

case that slides in and out of the handle like it's mounted on a ball-bearing drawer slide. **Dislikes:** Nothing noted.

ROCKWELL
LITHIUM TECH
RK2510K2

Price: \$130
½-in. holes: 160
2½-in. screws: 164

Good and basic. That's how we'd describe the no-frills, no-nonsense Rockwell. A smooth speed-selector switch, crisp clutch ring, well-shaped trigger and twin batteries that mount and dismount easily are all present and accounted for, sir! Rocky offers pretty decent drilling and driving, too. **Dislikes:** Nothing comes to mind. Well, maybe the guacamole color.

RYOBI
HJP002K

Price: \$80
½-in. holes: 151
2½-in. screws: 184

Its neon-green color makes it easy to find in a pile of tools, and the numbers it racked up in our drilling and driving tests make it easy to like. It may not be the torquiest or the fastest tool, but it gets the job done. **Dislikes:** Needs a single-sleeve chuck—like almost every other drill in this category—to ease installing and removing bits.

SKIL
2412-01

Price: \$80
½-in. holes: 105
2½-in. screws: 150

We like the Skil's common-sense approach to product design. Take its two-speed switch, for instance. One setting says High Torque and shows a big flat-head screw. The other setting says High Speed and shows a drill bit. Another example is the big round chuck ring encased in rubber. It provides a sure grip and turns to each clutch setting with a satisfyingly crisp click. **Dislikes:** Nothing noted. **PM**



RATING ●●●●●



BEST OVERALL

RATING ●●●●●



BEST VALUE

RATING ●●●●●



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RATING ●●●●●



RATING ●●●●●



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(sildenafil citrate) tablets

WITH EVERY AGE COMES RESPONSIBILITY. IMPORTANT SAFETY INFORMATION BELOW.

We know that no medicine is for everyone. Don't take VIAGRA if you take nitrates, often prescribed for chest pain, as this may cause a sudden unsafe drop in blood pressure.

Talk with your doctor first. Make sure your heart is healthy enough to have sex. If you have chest pain, nausea, or other discomforts during sex, seek medical help right away.

In the rare event of an erection lasting more than four hours, seek immediate medical help to avoid long-term injury.

In rare instances, men who take PDE5 inhibitors (oral erectile dysfunction medicines, including VIAGRA) reported a sudden decrease or loss of vision, or sudden decrease or loss of hearing. It is not possible to determine whether these events are related directly to these medicines or to other factors. If you experience any of these symptoms, stop taking PDE5 inhibitors, including VIAGRA, and call a doctor right away.

The most common side effects of VIAGRA are headache, facial flushing, and upset stomach. Less common are bluish or blurred vision, or being sensitive to light. These may occur for a brief time.

VIAGRA does not protect against sexually transmitted diseases including HIV.

Please see Important Facts for VIAGRA on the following page or visit viagra.com for full prescribing information.

^{*}Data taken from the *Massachusetts Male Aging Study*. Of 1,290 respondents, 52% stated that they had some degree of ED.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.FDA.gov/medwatch or call 1-800-FDA-1088.

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StoreNags.com

IMPORTANT FACTS

VIAGRA[®]
(sildenafil citrate) tablets

(vi-AG-rah)

IMPORTANT SAFETY INFORMATION ABOUT VIAGRA

Never take VIAGRA if you take any medicines with nitrates. This includes nitroglycerin. Your blood pressure could drop quickly. It could fall to an unsafe or life-threatening level.

ABOUT ERECTILE DYSFUNCTION (ED)

Erectile dysfunction means a man cannot get or keep an erection. Health problems, injury, or side effects of drugs may cause ED. The cause may not be known.

ABOUT VIAGRA

VIAGRA is used to treat ED in men. When you want to have sex, VIAGRA can help you get and keep an erection when you are sexually excited. You cannot get an erection just by taking the pill. Only your doctor can prescribe VIAGRA.

VIAGRA does not cure ED.

VIAGRA does not protect you or your partner from STDs (sexually transmitted diseases) or HIV. You will need to use a condom.

VIAGRA is not a hormone or an aphrodisiac.

WHO IS VIAGRA FOR?

Who should take VIAGRA?

Men who have ED and whose heart is healthy enough for sex.

Who should NOT take VIAGRA?

- If you ever take medicines with nitrates:
 - Medicines that treat chest pain (angina), such as nitroglycerin or isosorbide mononitrate or dinitrate
- If you use some street drugs, such as "poppers" (amyl nitrate or nitrite)
- If you are allergic to anything in the VIAGRA tablet

BEFORE YOU START VIAGRA

Tell your doctor if you have or ever had:

- Heart attack, abnormal heartbeats, or stroke
- Heart problems, such as heart failure, chest pain, or aortic valve narrowing
- Low or high blood pressure
- Severe vision loss
- An eye condition called retinitis pigmentosa
- Kidney or liver problems
- Blood problems, such as sickle cell anemia or leukemia
- A deformed penis, Peyronie's disease, or an erection that lasted more than 4 hours
- Stomach ulcers or any kind of bleeding problems

Tell your doctor about all your medicines. Include over-the-counter medicines, vitamins, and herbal products. Tell your doctor if you take or use:

- Medicines called alpha-blockers to treat high blood pressure or prostate problems. Your blood pressure could suddenly get too low. You could get dizzy or faint. Your doctor may start you on a lower dose of VIAGRA.
- Medicines called protease inhibitors for HIV. Your doctor may prescribe a 25 mg dose. Your doctor may limit VIAGRA to 25 mg in a 48-hour period.
- Other methods to cause erections. These include pills, injections, implants, or pumps.
- A medicine called REVATIO. VIAGRA should not be used with REVATIO as REVATIO contains sildenafil, the same medicine found in VIAGRA.

POSSIBLE SIDE EFFECTS OF VIAGRA

Side effects are mostly mild to moderate. They usually go away after a few hours. Some of these are more likely to happen with higher doses.

The most common side effects are:

- Headache
- Feeling flushed
- Upset stomach

Less common side effects are:

- Trouble telling blue and green apart or seeing a blue tinge on things
- Eyes being more sensitive to light
- Blurred vision

Rarely, a small number of men taking VIAGRA have reported these serious events:

- Having an erection that lasts more than 4 hours. If the erection is not treated right away, long-term loss of potency could occur.
- Sudden decrease or loss of sight in one or both eyes. We do not know if these events are caused by VIAGRA and medicines like it or caused by other factors. They may be caused by conditions like high blood pressure or diabetes. If you have sudden vision changes, stop using VIAGRA and all medicines like it. Call your doctor right away.
- Sudden decrease or loss of hearing. We do not know if these events are caused by VIAGRA and medicines like it or caused by other factors. If you have sudden hearing changes, stop using VIAGRA and all medicines like it. Call your doctor right away.
- Heart attack, stroke, irregular heartbeats, and death. We do not know whether these events are caused by VIAGRA or caused by other factors. Most of these happened in men who already had heart problems.

If you have any of these problems, stop VIAGRA. Call your doctor right away.

HOW TO TAKE VIAGRA

Do:

- Take VIAGRA only the way your doctor tells you. VIAGRA comes in 25 mg, 50 mg, and 100 mg tablets. Your doctor will tell you how much to take.
- If you are over 65 or have serious liver or kidney problems, your doctor may start you at the lowest dose (25 mg).
- Take VIAGRA about 1 hour before you want to have sex. VIAGRA starts to work in about 30 minutes when you are sexually excited. VIAGRA lasts up to 4 hours.

Don't:

- Do not take VIAGRA more than once a day.
- Do not take more VIAGRA than your doctor tells you. If you think you need more VIAGRA, talk with your doctor.
- Do not start or stop any other medicines before checking with your doctor.

NEED MORE INFORMATION?

- This is only a summary of important information. Ask your doctor or pharmacist for complete product information OR
- Go to www.viagra.com or call (888) 4-VIAGRA (484-2472).

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Homeowners Clinic

by Roy Berendsohn

Q+A

Seeing the Light

Q

I keep flashlights stored all over the house because we lose power often in our neighborhood, and at least half of the outages occur at night. What's the best way to store a flashlight so I can find it in the dark?



A glow-in-the-dark flashlight mount is easy to make and can be a godsend during a blackout.

cent acrylic create a good beacon, but if I ever install another setup elsewhere in the house, I'd go with three coats for even greater brightness—and ease of finding my way in the dark.

Universal Drill

➔ Is there one drill bit that works with multiple materials, including wood, metal and concrete? I want to carry a single type of bit, if possible.

There are at least two drill bits on the market that claim to be effective with all materials. Bosch calls its version "multi-construction," and Artu—which says its bits will even bore through glass—uses the label "multipurpose." Both manufacturers say the products can be used in rotary or percussion mode, though you obviously wouldn't want to put a hammer drill to glass! For either brand, a five-bit set costs \$18 to \$25, depending on your point of purchase.

I lug around a lot of tools, so I understand why you'd want to simplify your kit with a universal bit. In fact, I get a lot of use out of my multipurpose tools and accessories. But I do employ dedicated bits and blades depending upon whether a job demands precision, speed or cleanliness. When drilling large holes in lumber, for instance, I reach for a razor-sharp auger bit.

Regardless, I still believe in general-purpose bits. A 13-piece set of M2 high-speed steel bits (\$10 to \$12) can be an asset to anyone who's handy with a drill. With a tip geometry of 118 degrees, they'll readily bore through wood and even steel. Incidentally, when drilling steel, use cutting fluid; if you're using the tool at an angle or drilling

A Yep, a flashlight will do you absolutely no good unless you can find it in the dark. The photo above shows the simple setup I use at home. The flashlight holder consists of nothing more than a 1-foot-long piece of 1 x 4 pine with a Maglite D-cell flashlight mounting bracket screwed to it. The brackets are sold by the pair; they have a sure grip, so one suffices for a wall attachment, but you might want to use two if, for instance, you're hitching a flashlight to the interior of your car, truck or boat. In lieu of the all-purpose screws packaged with the brackets, I used No. 8 ¾-inch round-head wood screws. I affixed the mounting block to the wall with two self-drilling No. 8 2½-inch wood screws. The rig might appear to be overkill, but it's merely built to last. Unless you fasten the bracket firmly to the block and the block tightly to the wall, you'll loosen the holder the first time you remove the flashlight.

I beveled the edge of the wood block, painted it the same color as the wall and applied a stripe of glow-in-the-dark paint on the ends. Two coats of the phosphores-

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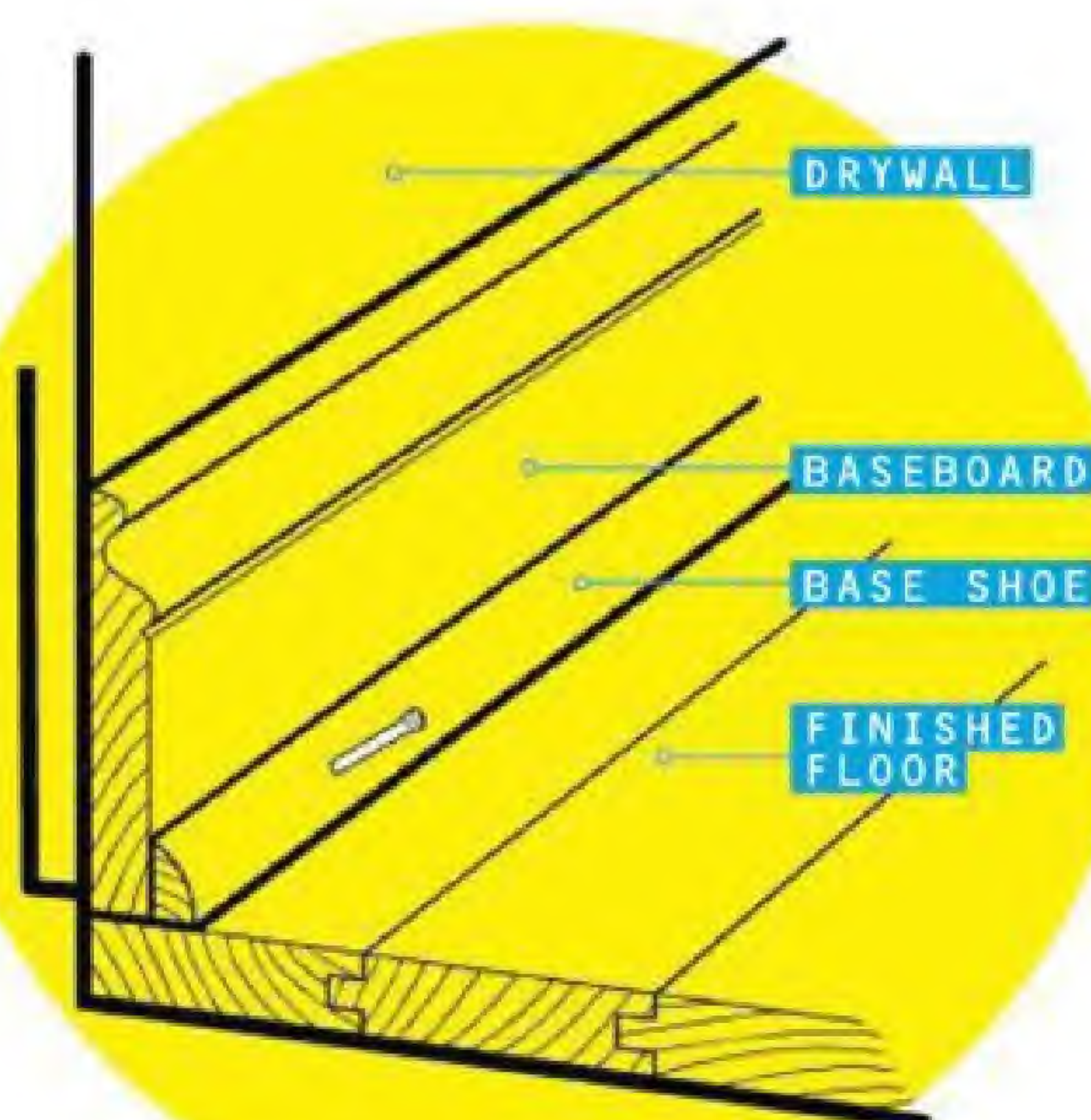
Trimming the Confusion

➔ I'm going to install some new baseboard, door and window trim. Which is better to trim the bottom of the baseboard, quarter-round or base shoe molding? I really don't see much difference between the two.

I prefer base shoe molding, in part because it has a more elegant look than quarter-round. Also, as its name implies, the quarter-round is shaped like a quarter of a circle (well, technically, a cylinder), so it can be tough to drive a nail through it and into the baseboard. Base shoe molding, on the other hand, has a broad vertical surface that is easier to nail.

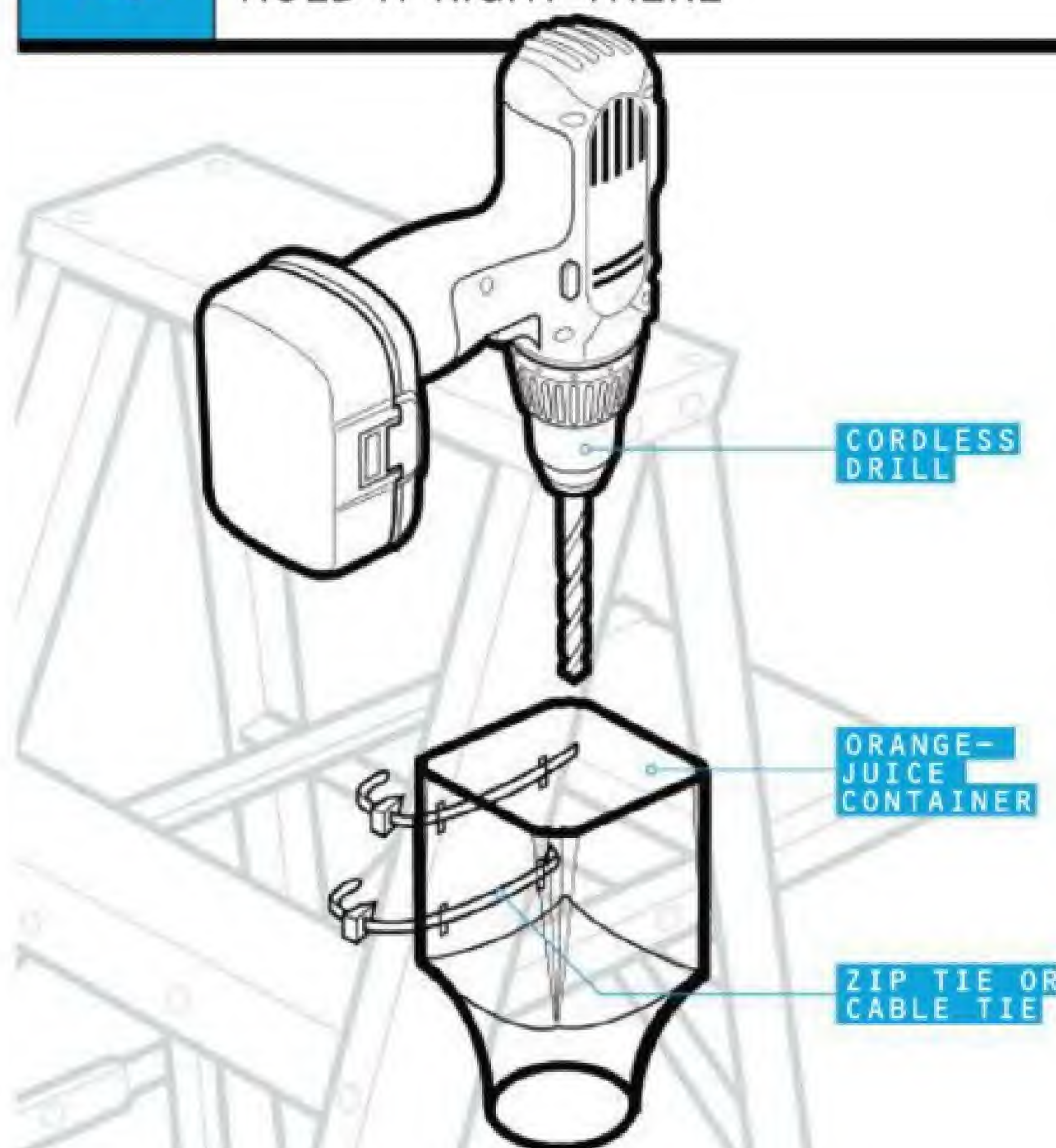
I understand why some people prefer quarter-round. It's as flexible as rope, a useful quality when working with a wavy floor, for instance. But the lack of a flat nailing surface can be a major drawback: Unless you're using a pneumatic finish nailer, the molding can easily split or, at least, suffer hammer dents. Assuming I've made a good case for shoe molding, install it by nailing it not to the floor but to the baseboard. This allows the floor to expand and contract freely, with no negative impact on the molding.

Since I don't know the size of the molding you're installing, it's tough for me to recommend a nail size, but my guess is that 4d will do the trick.



THE RECYCLER

HOLD IT RIGHT THERE



Resourcefulness is among the many qualities a good Marine possesses. And Ed Buschmann of Wayne, N.J., should know. The former leatherneck used a plastic juice jug to rig up a cordless drill holster, then attached it to his ladder for easy access.

How to make it:

- Slice off the container's top and bottom.
- Cut four slits in a rectangular pattern into one side of the jug.
- Use two zip ties to lash the holster to one of the ladder's legs.

Lost and Found ➔ We recently moved and I brought some blinds from the previous house to install in our new place, but I lost the mounting hardware in the move. The blinds were quite expensive (about \$300 for three), and my local hardware store doesn't stock what I need for the job. Is it worth it to try and make my own mounting brackets, or should I just buy new blinds?

The first thing I'd do is look around on the Web (try blinds.com) or contact the retailer that sold you the blinds. Some online retailers sell hardware separately, and if you bought the blinds in a bricks-and-mortar store, it can't hurt to ask. Other general sources, such as Aubuchon Hardware, carry an extensive selection of hardware for drapery and blinds. If you have to fabricate the parts, I suggest modifying an existing bracket or other piece of hardware. Just drill, saw and grind it to fit your needs. Over the years I've done this with joist brackets and metal angles, and it's not as difficult as you might think. One word of advice, though. Carefully clamp the piece you're working on to ensure that the drill bit, saw blade or grinding wheel doesn't send it flying.

Lightning Strikes Twice

➔ We get a lot of thunderstorms where we live, and when lightning strikes nearby, our six smoke detectors go off. The house was built in 2007, and the two electricians I've spoken to can't solve the problem. Please help!

You've probably heard the expression that electricity follows the path of least resistance. That's what's happening here. The grounding system outside your house isn't working properly; instead, it's conducting the currents caused by the lightning into your

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DIY

Home HOMEOWNERS CLINIC Q+A

house, which is precisely the opposite of what should be happening. The energy surge sets off your smoke detectors, which are basically current-reading devices. "Some fire and security alarm systems are triggered by what they perceive as a test input," according to Joe Cristino, P.E., an electrical engineer in Redding, Conn., who specializes in power systems. "The problem can be difficult to eliminate, but you should be able to minimize it to an occasional sounding."

Before I explain how your problem can be fixed, I'd like to provide some background. A lightning bolt strikes with an electromotive force of up to 300 million volts. The currents it creates can move through the earth, the electrical grid, household electrical systems and metal structures. Computers, televisions and appliances and portions of a home's electrical system can be roasted by the massive surge. Those currents aren't supposed to get into your house; they're supposed to dissipate into the earth through large metal stakes, known as ground rods, connected to the house's grounding system.

Fixing the problem requires calling in a professional who specializes in installing lightning-protection systems. The pro will test the conductivity of the soil around the house, then design and install a low-resistance grounding system. The electrician may also put in a transient-voltage surge suppressor on the main disconnect at your home's service panel. This device diverts and absorbs excess currents, otherwise known as a surge or transient surge.

Finally, the electrician will check the house's "bonding"—the screws, bolts, clamps, bushings and short lengths of wire linking the home's metal components that do not normally carry current. These parts should be configured to form an electrical path that grounds

stray currents, rather than letting them course through your home's wiring, plumbing, sheet-metal ducts or heating and cooling equipment.

Roll With It

⚙️ **Sometimes when I use a paint roller on a smooth surface—when I was recently painting some doors, for example—it slides like a squeegee. What can I do to prevent this?**

Many products perform at their best right out of the box. But a select few, including paint-roller covers, get better over time. "A high-quality paint-roller cover will improve with use," confirms Bruce Schneider, a painting trainer and marketing manager for Purdy Corp., a manufacturer of roller covers and brushes based in Cleveland. "Using and cleaning the cover improves its yarn and makes it more absorbent. This helps the cover to hold and release the paint properly, so that the coating can be rolled onto the surface rather than pushed along it."

So do what the pros do: Precondition a roller before you get down to business. If you're using latex paint, saturate the roller with water and spin out the excess. If you're using an alkyd or other chemical-solvent paint, use paint thinner or other prescribed solvent to prep the roller. Pretreatment washes out loose fibers left in the roller from the manufacturing process. These yarns can mar the finish the first time you use a roller cover.

Another tip: Don't overload the roller with paint. The excess runs off the cover and forms a puddle that makes the roller more likely to slide than to turn properly around its axle. To get the right amount of paint on the roller, dip it in paint and roll it back and forth on the tray ridges before application. Finally, don't use a too-thick nap on slick surfaces. **PM**

?

Got a home-maintenance or repair problem? Ask Roy about it. Send your questions to pmhomeclinic@hearst.com or to Homeowners Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.

HOW YOUR HOUSE WORKS

→ Fireplace

Keeper of the Flames

THE 21ST-CENTURY FIREPLACE REVEALS MODERN UPDATES TO MAN'S OLDEST SOURCE OF HEAT, COMFORT, CUISINE AND CULTURE.

BY HARRY SAWYERS



➔ **Classic brick-and-mortar** fireplaces aren't exactly hot these days, according to Joe LaVecchia of New Jersey's Abbey Hart Brick & Stone. "We used to sell a million firebricks a year in the 1970s," he says. "Now it's more like eighty or a hundred thousand."

It's not that the hearth's allure has been extinguished—it's a cost issue. Between the prerequisite concrete foundation and a mason to do the job, a traditional fireplace can cost \$10,000 to \$15,000 to install. Then there's efficiency. Typical fireplaces draw and vent interior air that a homeowner pays to heat with a furnace. The image of dollar signs streaming out of a chimney comes to mind.

The most common alternative today is the fuel-efficient, direct-vent gas fireplace. Carpenters can install the prefab firebox, which costs a fraction of a traditional fireplace. Still, nothing duplicates a crackling hearth. The old flame—fascinating and elemental—dies hard.

INSIDE

→ BRICKS → DAMPERS → FLUES
→ DIRECT-VENT FIREPLACES
→ CHIMNEY SWEEP FAQ
→ HEARTH HISTORY → WOOD BY BTU

CHIMNEYS: THE INSIDE STORY

FLUE Smoke rises through ceramic flue liners in about 95 percent of brick chimneys, Tyler McClave of flue-maker Superior Clay says. Round models span 3 to 36 inches in diameter; rectangular flues get as big as 24 x 24. But a 12 x 12 square is typical, and two flues often run side by side in a single chimney.

SMOKE SHELF Wood smoke rises from the firebox and collects along the smoke shelf, a horizontal termination that prevents smoke from traveling downward from the chimney and into the house. Located about 8 inches above the top of the firebox, the shelf has a concave surface that collects rainwater and debris.

DAMPER The metal door atop the firebox closes when the fireplace is dormant to seal the drafty chimney from the home interior. It's not a perfect seal, McClave says, because a refrigerator-style rubber gasket can't last in intense heat. Common-sense note: Never light a fire with the damper closed.

FIREBRICK Also known as refractory brick, firebrick has an inherent ability to expand and contract with rapid heating and cooling. Face brick, which clads chimneys, cracks and fails when used to line a firebox.

HISTORY OF THE HEARTH

1 B.C.

➔ Roman hypocausts domesticate flames, using smoke and steam to heat stone floors.

1547

➔ Francis I's French royal winter palace in Chambord is complete—with 365 fireplaces.

1631

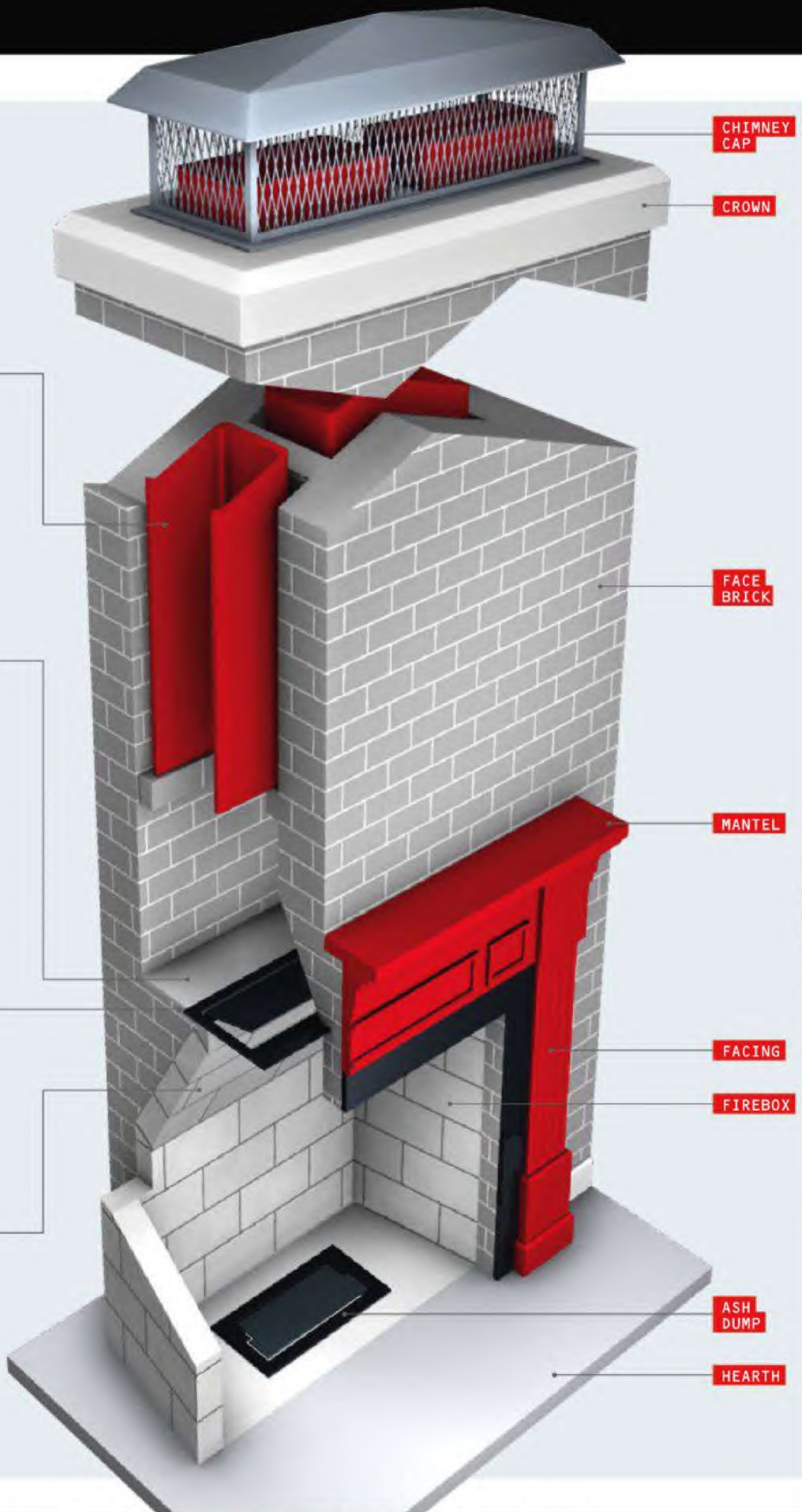
➔ Boston house fires lead to a ban on thatched roofs and wattle-and-daub chimneys.

1741

➔ Benjamin Franklin invents his eponymous stove, a fireplace that circulates air to boost heat.

1776

➔ Headachy Continental Congress delegates banish stoves from Independence Hall.



EFFICIENCY AIDS

➔ Nearly 80 percent of the heat a fireplace generates goes up the chimney rather than radiating into a room. Cut down waste with blowers, which move heat from the firebox out to the room, and tap into the chimney's radiant-heat potential with a grate that stacks logs up against the bricks. When the fire dies, close a set of glass doors, which help seal cool, drafty flues.



DIRECT-VENT GAS FIREPLACE

PROS

Concentric pipes draw in outdoor air and expel exhaust gas. Natural gas or liquid propane fuels flames in a sealed chamber. Ceramic-fiber logs glow without burning. The box reaches full heat in only 15 minutes.

CONS

Lacks the fun of the bellows, a poker and a smoky aroma. Tempered-glass-face temperatures approach 500 F, a burn risk, especially for children. The manufacturer Lennox now offers free protective screens.

\$\$\$

About \$1700 a unit; \$3500 installed

ASK A CHIMNEY SWEEP

WHY IS MY FIRE SO SMOKY?

Step one is to open the damper, Chimney Sweep Inc. president Tom Oyen says. The other common problem is insufficient updraft—try opening closed doors (or windows) in a room with a smoky fireplace.

WHEN DO I NEED A SWEEP?

Have the chimney swept annually, or as every two cords of wood are burned, Oyen says. Burn seasoned wood to slow creosote buildup.

WHAT'S SEASONED WOOD?

Ideal wood has 20 to 25 percent moisture content. "It should burn end to end, like a cigar," Oyen says.

HOW DO YOU SWEEP IT?

"Brushes and a shop vac. We carry 14 sizes of 22-gauge wire brushes," Oyen says. "We seal the firebox and work from the top down. The tines fit snugly to pop the creosote loose. The soot settles, and we vacuum the fireplace with a 0.5-micron filter."

BTU BREAKDOWN

BLACK LOCUST

\$235/CORD

Fast-growing and heat-dense with 27.9 million Btu per cord, black locust is an excellent firewood with one caveat: It's very tough to split.

CHERRY

\$300/CORD

With a nice fragrance, few sparks and low resistance to splitting, cherry has only one big drawback: low energy density, just 20.4 million Btu per cord.

ROCK MAPLE

\$250/CORD

A nice hardwood popular on the East Coast, maple is easy to split and makes excellent, long-lasting coals. It averages about 25 million Btu per cord.

ASH

\$250/CORD

Ash has low smoke, a mild fragrance and 24.2 million Btu of heat per cord. It's usually part of a New England woodpile.

WHITE OAK

\$290/CORD

Red or white oak—with low smoke, minimal sparks and 29.1 million Btu per cord—is fine firewood available throughout the U.S.

1792

Shallow firebox and narrow flue define the Rumford, a new (and still popular) fireplace.

1850

➔ Firewood accounts for 90 percent of America's home-heating and cooking fuel.

1933

➔ President Franklin D. Roosevelt delivers the first of 30 fireside chats: "On the Bank Crisis."

1988

➔ The remote-control gas fireplace stokes an ongoing pro-gas trend.

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DIY

Home PM SATURDAY

The Ultimate Stocking

UPDATE THE STANDARD SOCK WITH A BULLETPROOF VERSION STRONG ENOUGH TO HOLD EVERYTHING SANTA CAN PILE INSIDE. BY WILLIAM GURSTELLE



2 → CUT AND PASTE

Double the strength of the envelopes by gluing together two pairs of inside-out Tyvek bags (one inside another) with Duco Cement. Cut off the lower left corner of one envelope pair. Fold and glue a lower corner of the second envelope pair into a tapered stocking tip. Cut off the top flap of the lower envelope and fit it over the upper envelope's open corner, adjusting the fit until it all looks sock-like. Apply plenty of cement along the seams and lightly press the pieces together. Wipe away the excess cement. Let dry.

1 → STOCK THE STUFF

Nothing beats a bulging stocking on Christmas morning, but the traditional cloth design can hold only so many goodies. This super stocking redeploys the tough Tyvek FedEx envelopes that arrive with holiday gifts. Fully loaded, the fibrous polyethylene sock holds 50 pounds. That's enough for a generous load of toys, sugarplums or even coal. Gather up four 15 x 12-inch envelopes, a ¼-inch eyebolt for wood or masonry (depending on the mantel), an S-hook, Duco Cement, eight grommets and a tough, ¼-inch-diameter nylon rope.

3 → HANG WITH CARE

Fold and glue down the adhesive sealing flap on the top envelope. Install eight grommets through the double layer on the top edge. Drive the eyebolt into the mantel. Thread the nylon rope through the grommets and tie it up. Use the S-hook to hang the rope from the eyebolt.

4 → GET FESTIVE

To decorate the outside of the stocking, use rivets or Sharpies to write in a name—or a wish list.



+ MORE TO DO IN DECEMBER

Make a Simple Sled

→ Sleds sell out once the snow falls, but corrugated cardboard can give a good ride. Apply duct tape to the underside and slick it up with ski wax. Alternate options: garbage can lids and cafeteria trays.

Do a Furnace a Favor

→ Use pleated-paper (not fiberglass) furnace filters, says 40-year HVAC pro Leon Kelly of Plains Heating and Air Conditioning. Plan to replace the filter once a month in the winter, Kelly says.

Trim the Tree

→ A Christmas tree can drink a quart of water a day, according to the National Christmas Tree Association. Saw ½ inch off a new tree's trunk to aid water consumption and reduce fire risk.

Let Boys Bag Bucks

→ Virginia teens try out whitetail hunting, learn firearm safety and enjoy venison chili during the Novice Youth Deer Hunt and Workshop, Dec. 10 at the Occoquan Bay National Wildlife Refuge in Woodbridge, Va.

Time the Lights

→ Install light timers on random bulbs to keep the house lit during holiday travels. With winter's early sunsets, a dark house is an invitation to thieves and vandals. The neighbors will thank you.

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WINTER

The Myth of the All-Season Tire

A HEAD-TO-HEAD COMPARISON IN
NORTHERN MINNESOTA PROVES
ALL-SEASON TIRES REALLY AREN'T.

BY BEN WOJDYLA

➔ **Back in 1977**, Goodyear introduced the Tiempo, the first tire dubbed all-season. The idea was simple and alluring: Instead of dealing with the hassle of switching between snow and summer tires as the seasons change, drivers could use one tire all the time. Sales skyrocketed and other companies quickly followed suit. These days nearly all vehicles sold in the United States are fitted with all-season tires from the factory, and 97.5 percent of replacement-tire sales are the same. But is that such a good idea? Actually, no. It turns out that all-season tires are fine in warmer months, but in the snow, they lack traction compared with dedicated snow tires. And that means that the millions of drivers who make do with all-season tires in the winter months are driving cars that aren't as safe as those shod with tires designed for icy conditions.

Snow flies in Baudette, Minn., as we put all-season and winter tires to the test—and have a good bit of fun doing it.

INSIDE



TICKING TAPPETS + SCRATCHED WINDSHIELD + REMOVAL-RESISTANT NUTS

DIY **Auto** TIRE TEST

We know because we traveled to northern Minnesota, home of some of the nation's harshest conditions, to test the claim of the all-season tire. And since all-wheel drive is rapidly becoming a common option, we also tested the notion that the feature is a suitable substitute for snow tires. Our assumption was that, while AWD improves some aspects of winter performance, it doesn't help a car turn or stop, and the added weight of the mechanical bits can actually be a disadvantage. Common sense and physics suggested this to be true, but nothing proves a point like data. And the best way to gather data on winter-tire performance is to find yourself an icy, snowy proving ground.

Ice Driving

➔ **There's something** foreboding about traveling to a place so cold it's called the Ice Box, but Baudette, Minn., was the perfect place to run our experiments. The sprawling Automotive Enviro Testing facility there specializes in frigid-weather testing for many large auto manufacturers. With a five-month winter season, the facility can maintain enormous snow and ice surfaces kept within strict tolerances by GPS-controlled tractors towing custom-built ice- and snow-grooming systems—basically the world's largest Zambonis.

To set a level playing field, we brought along two nearly identical four-cylinder 2011 Chevy Equinoxes—one optioned with front-wheel drive, the other with AWD. We ran both through a series of tests to measure acceleration, braking, hill-climb and turning ability. The cars were first outfitted with Goodyear all-season tires, then we ran the tests again with Goodyear snow tires. We ran each test numerous times and then averaged the results. To minimize the variables, the same driver performed all the tests, and the traction- and stability-control systems were left on. Data collection was completed with the industry standard VBox—a GPS and accelerometer-based data logger.

TIRE TESTING

WINTER vs ALL-SEASON

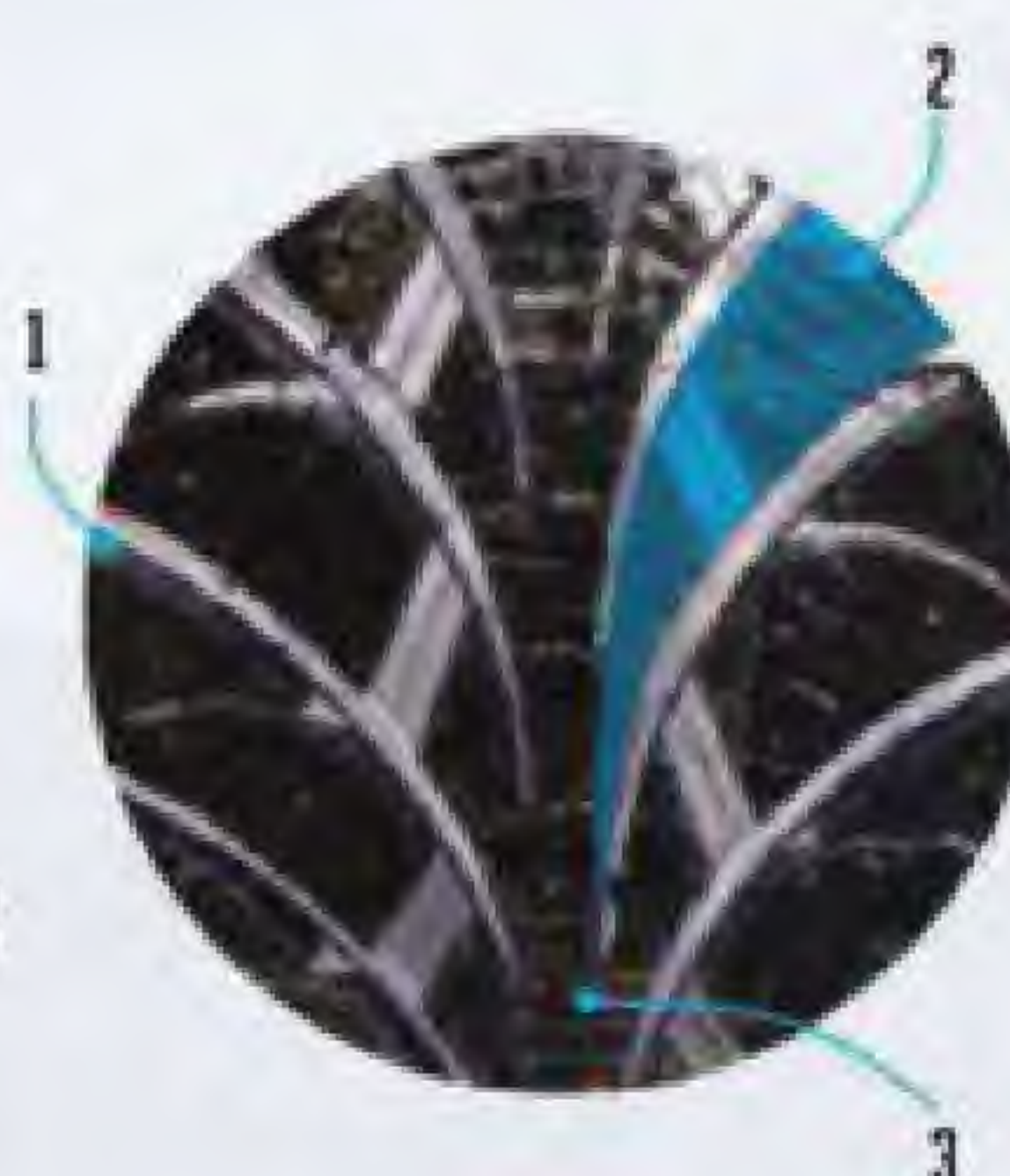
Like all engineered products, tires balance design elements to maximize intended performance. Here's a rundown of the main differences between all-season and winter tires.

The difference in **winter tires** starts with the rubber compound, which remains flexible during cold weather rather than hard like all-seasons. Deep grooves (1) in the unidirectional tread blocks (2) clear snow and slush efficiently; small cuts, called sipes (3), grip tiny variations in slick surfaces.

All-seasons wear longer because of harder rubber compounds. Drainage channels (1) limit hydroplaning; fewer grooves (2) mean better dry-surface grip. Bidirectional tread (3) allows tires to be rotated to both sides of the car.



Goodyear Ultra Grip Ice
235/65R17

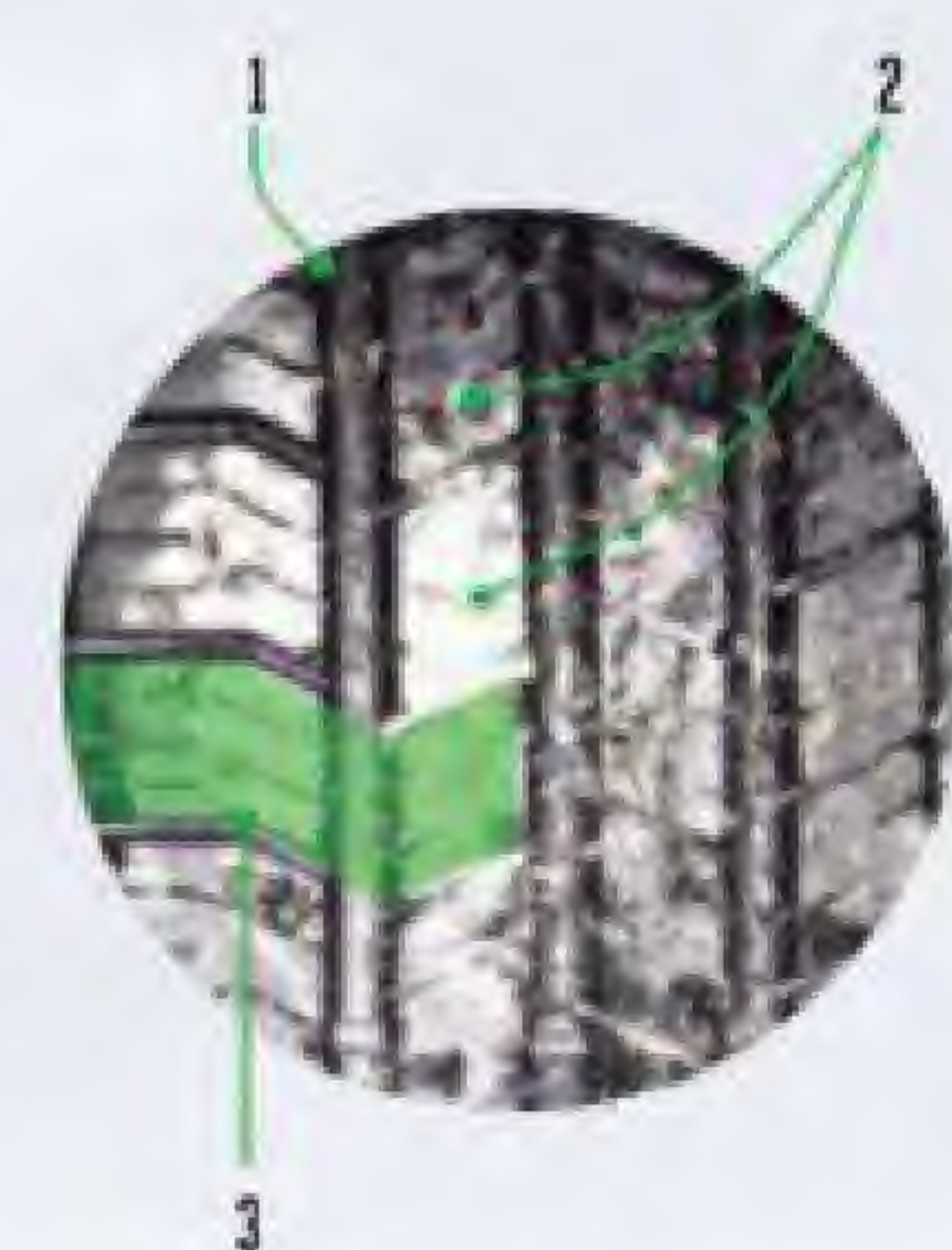


WINTER

ALL-SEASON



Goodyear Integrity
P235/65R17



1

60-0 MPH
Braking

AWD

WINTER 366 feet, 7.97 sec
ALL-SEASON 387 feet, 8.50 sec

FWD

WINTER 374 feet, 8.17 sec
ALL-SEASON 383 feet, 8.62 sec

➔ "I'll be fine, I have all-wheel drive." It's called all-wheel drive instead of all-wheel stop for a reason. On all-seasons, the AWD car stopped in the longest distance. On snow tires, both cars came to a halt about a car length sooner—often the difference between a close call and a call to your insurance company.

THE SETUP



VEHICLES
2011 Chevy Equinox four-cylinder AWD

• 2011 Chevy Equinox four-cylinder FWD



LOCATION
Automotive Enviro Testing, Baudette, Minn.



OUTDOOR TEMP RANGE
18 F–27 F



CONDITIONS
Packed snow with milled-ice underlay

THE TESTS

1

60–0 mph Braking

2

0–60 mph Acceleration

3

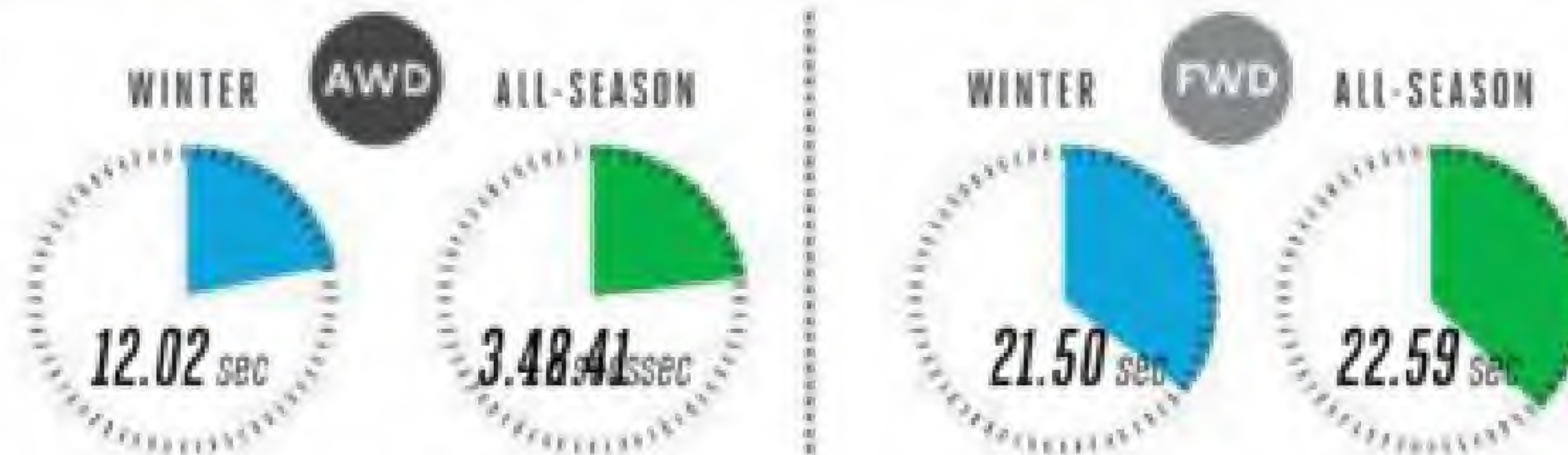
Snowpacked Skidpad

4

10 Percent Hill Climb

2

0-60 MPH Acceleration



→ Getting moving can be difficult when the only traction you have is on snow. In this test, the all-wheel-drive vehicle had a significant advantage over the front-wheel-drive version—no surprise there—but the half-second improvement with the winter tires was bolstered by more stable vehicle behavior.



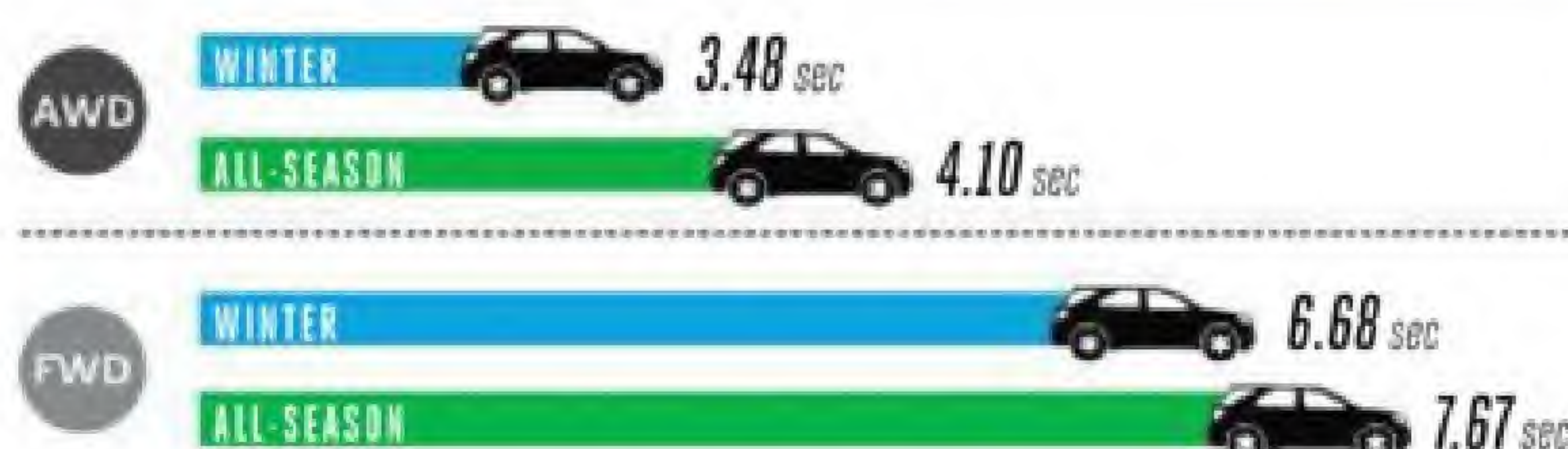
3

Snowpacked Skidpad

→ Cornering to drive around obstacles is important for avoiding winter accidents. Racing around a 280-foot-wide circle shows that all-wheel drive helps, but not as much as the winter tires. Our AWD tester with all-seasons was bested by the FWD car with winter tires.

4

10 Percent Hill Climb



→ When climbing snowy hills, more tire grip means traction control has less work to do, which gets you up the hill faster. We sent our SUVs up a 100-foot 10 percent grade, measuring how fast each reached the top. Here, AWD made a big difference, but AWD with winter tires was even better.



The Bottom Line

→ In a contest between all-season and winter tires driven on snow and ice, the latter won the day. Although the year-round rubber performed admirably, it's clear in all situations that with either FWD or AWD there's a substantial advantage to having proper rubber under you. The results were especially striking during braking and cornering, when snow tires improved performance by up to 5 percent and 20 percent, respectively.

Buying and living with winter tires isn't that much of an inconvenience, but there are some guidelines you should follow:

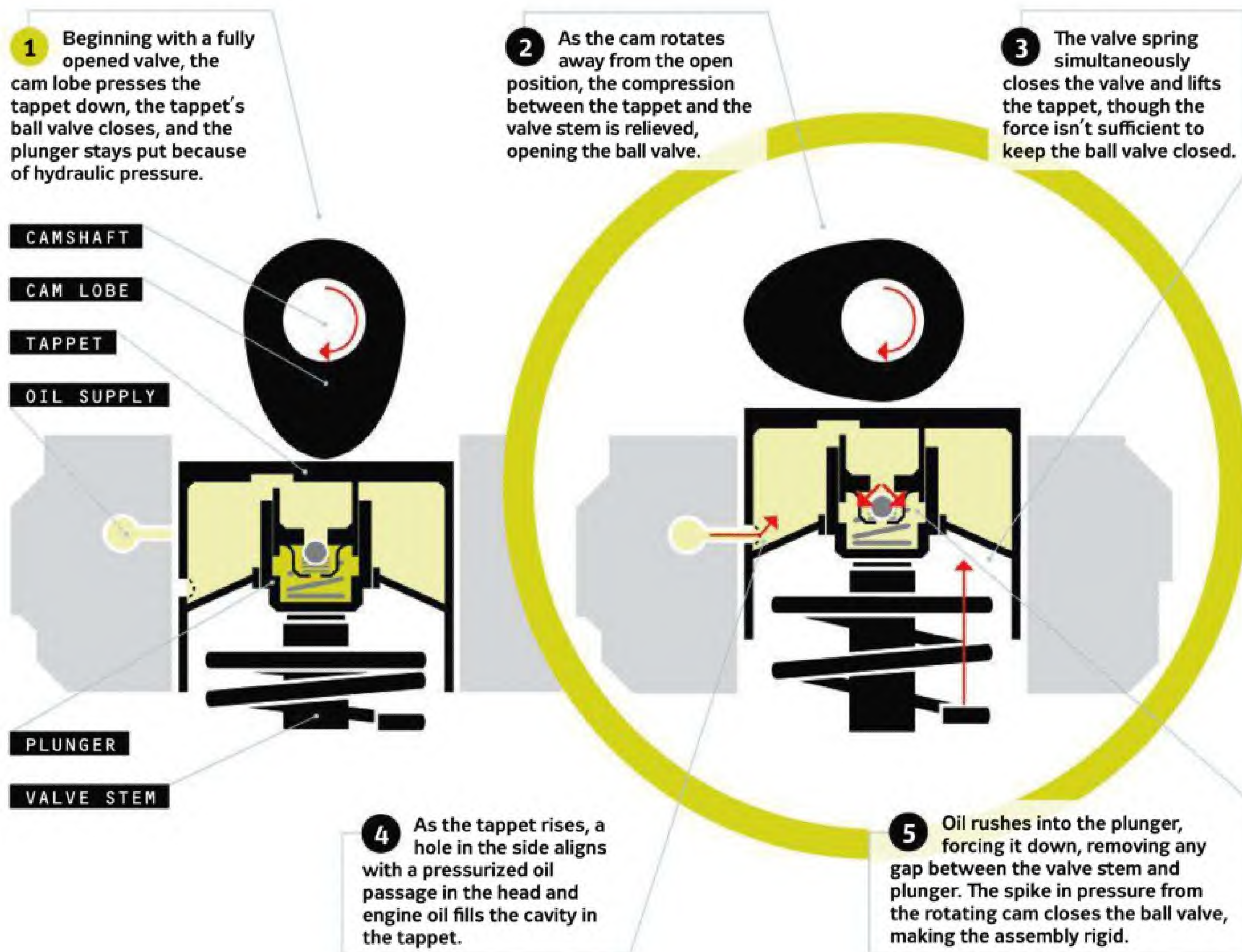
- If you live anywhere north of the Mason-Dixon line, it's probably worthwhile to invest in winter tires.
- Make sure you buy four tires; skimping and putting winter tires only on the drive end of the car will result in unpredictable handling and could be dangerous.
- If you'd rather not remount your tires each season, pick up a separate set of inexpensive steel wheels for permanent winter-tire duty. (This also keeps expensive alloy wheels from getting damaged in harsh, salty winter conditions.)
- Swap to winter tires around Thanksgiving and back to all-season or summer tires around Easter—winter tires' softer rubber compounds wear quickly in warmer temperatures.
- Store off-season tires in a cool, dry area out of the sun, and consider wrapping them in black plastic bags to reduce oxidation.
- Keep in mind that having two sets of tires isn't doubling the expense, it's halving the wear. You'll have twice the number of tires but buy new ones half as often.
- Remember, fancy new tires or not, the standard winter driving advice still applies: Slow down, double your following distances, anticipate traffic changes ahead, and give yourself extra time to get where you're going. Good luck out there!

PM

Car Clinic

by Ben Wojdyla

Q+A



Q

The Tale of the Ticking Tappets

I have a 1986 Saab 900. The car had been sitting for a while, and when I started it there was a pronounced ticking noise from the engine. A friend said it might be a lifter and I should run the engine to see if the problem would go away. Unfortunately, after

running the engine for a bit the sound didn't go away. The guys from Saab enthusiast websites suggest adding Marvel Mystery Oil to the crankcase. Will that work?

A That ticking you hear is your Saab's hydraulic tappets (lifters serve the same purpose for a pushrod engine). These devices were introduced in the '30s, but became wildly popular in the '80s as improved reliability became an important selling feature. They're an innovative way to solve an old problem: how to keep valves properly adjusted. Depending on the engine, either the end of a rocker arm or the camshaft lobe pushes the valve open. The degree of the valve opening is a precise measurement, and over time the parts wear, so the valve opens less than

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We still change our own oil because, well, it's cheaper than therapy. And this formable funnel makes the process even more enjoyable because it catches the fluid that inevitably spills from the filter and coats the car's underside.

griotsgarage.com

is optimum. That's why valves used to need periodic adjustment—a fiddly job that required removing the valve cover, measuring the clearance, and either turning a set-screw or installing shims. Now we have self-adjusting hydraulic tappets placed on top of the valve stems.

These little devices consist of a piston inside a cylinder, which is fed oil pressurized by the engine's oil pump. The oil fills a low-pressure chamber in the top of the tappet. A ball valve between the low- and high-pressure chambers opens if there's any gap between the bottom of the tappet and the valve stem, and oil flows in, adjusting the length of the tappet to the proper setting. Since oil's volume doesn't change when it's compressed, the tappet acts like a solid link between the camshaft and valve.

The first suggestion to just let the car run was a good one. Often when a car sits, the oil in the tappets bleeds off, and it may take some time—a few seconds up to a minute or so—for them to "pump up" to adjust. In the meantime, that ticking noise results from slop in the system.

Since running your car didn't silence the ticking, in all likelihood those tiny moving parts and oil passages have gotten gummed up. Something in those lifters may be stuck. The solution? If you haven't done it already, change the oil. Then drive the car. A fresh batch of hot oil may clean out all the gunk.

If that doesn't work, do exactly what the guys on the enthusiast forums suggested: Add Marvel Mystery Oil. MMO claims many benefits when added to an engine, including the ability to clean varnishes away, as it can act as a solvent. Use up to a quart of MMO for every 3 quarts of oil. Can't find MMO? There are plenty of alternatives: Try Sea Foam, or just head down to your local auto parts store and

ask for the latest and greatest antivarnishing agent.

Hydraulic tappets rarely fail completely, but on the off chance the problem doesn't go away after these remedies, you may have to go through the expensive and time-consuming process of buying a new set of tappets, pulling off the valve cover and any associated accessories and camshafts, then replacing the entire set of tappets. If one fails, they're all suspect.

As for what's in Marvel Mystery Oil? It was developed by Burt Pierce in 1923 to clean clogged carburetor jets. It's a light-oil base with a blend of lubricants and solvents. Beyond that, its exact composition remains, well, a mystery.

Splitting a Headache ☺ I've been trying to replace my rusty and well-ventilated old exhaust system with a new one, starting after the manifold. Following many attempts to remove the nuts from the flange bolts, all I'm left with are rounded-off nuts and a garage full of profanity. Do you have any tips on how to remove these stubborn, rusted-on nuts?

Normally, applying a combination of penetrating oil, leverage and heat is enough to either free a nut or break the bolt; unfortunately, in your case more drastic and destructive measures seem necessary, even prudent. Allow us to introduce the nut splitter. It's a simple and effective device designed to split a nut down the side so it falls away, never to be used again. As a tool of last resort it should be used sparingly, but in this instance it's the right choice. Place the splitter over the nut, with the chisel point on one of the nut's flat sides, and tighten it with your fingers. Get an appropriate wrench and continue tightening the mechanism until the nut splits. Remove the tool, then discard the extricated nut.

Flickering Lights ☺ The dash lights on my 2009 Chevy Malibu come on only dimly in the daytime even though I have the rheostat knob turned all the way up. This makes it difficult to read the speedometer and other dials. The dash lights come on at full brightness when it's dark. Sometimes after I drive for about 30 minutes I'll hear a click under the dash and the lighting will come on. My dealer replaced the light sensor atop the dash, but that didn't remedy the

problem. I'd like to get this resolved while the car is still under warranty. May I have your thoughts, please?

This is a strange one, especially on such a new car. Usually when gauge clusters dim it's because they're old and the phosphors in the LCDs have worn out—they're sensitive to the heat buildup from the dashboard electronics and heating systems. Your problem

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sounds more like an electronic controls issue. The clicking sound you mentioned hearing under the dash leads me to believe it's not the sensor, but rather a relay between the car's body control module and the instrument panel. The body control module takes signals from the instrument panel light control (your rheostat) and the light sensor and sends a signal to set a certain level of

illumination. Contrary to what you might think, nighttime lighting is actually dimmer than daytime lighting. Manufacturers step the illumination down because the contrast at night is so much higher. If you have a bad relay, you aren't seeing full power at night, you're just seeing normal nighttime power all the time. That's a guess, but worth asking your dealer about.

The other option (especially since the car is under warranty) is to ask the dealer about replacing the gauge cluster. The subassembly is fairly expensive, but it's a relatively easy replacement. The problem could simply be a malfunction of the cluster's onboard electronics.

Scratching the Surface

I've got some light scratches in my windshield. My nail doesn't catch in them, so they're not deep, but the usual Windex is not having an effect. Can I buff these out? How?

There are two ways to address light scratches in glass. The easiest is to fill the scratches with an acrylic scratch remover, which is applied as a liquid and dries hard and transparent, hiding the damage by filling the scratches chemically. For deeper scratches, the most popular fix is buffing the glass with cerium oxide, a popular glass, ceramic and metal polish with very low abrasiveness—it's widely used in jewelry and ceramics. Add water to the fine powder and make a slurry the consistency of Elmer's Glue, then cover the damaged areas with the paste. Using a drill with a hard rubber polishing wheel attached, apply firm pressure to slowly grind the surface smooth. To make things a bit easier, mark the location of the scratch on the other side of the glass so you can keep track of where you should be working. It may take a while, but keep the paste moist and add more cerium oxide as needed, and the result will be a smooth, scratch-free surface.

PM

Got a car problem?

Ask Ben about it. Send your questions to pmautoclinic@hearst.com or over Twitter at twitter.com/PopMechAuto or to Car Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.

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Supercomputer

(CONTINUED FROM PAGE 89)

broke down so often that the facility switched to human-guided forklifts.

The Blue Gene/Q computers I'm getting a look at in midsummer are not part of Bruce Goodwin's supercomputer (named Sequoia). These are test models, used to work out the kinks in the hardware and software. The manufacturing of Sequoia's 96 racks was due to ramp up soon after my visit, but Goodwin and his team at Lawrence Livermore are already logging in to Blue Gene/Q and tinkering from afar; a sign on one of the racks in the Rochester assembly room says LLNL REMOTE ACCESS MACHINE.

Goodwin's Terascale Simulation Facility (TSF) at Livermore is one of two DOE centers that perform nuclear simulations as part of the Stockpile Stewardship Program (the other is at Los Alamos National Laboratory in New Mexico). To get a simulation that delivers an acceptable degree of accuracy, Goodwin's team models a 50-microsecond explosion in three dimensions down to a scale of 10 microns. "It gets very complicated," Goodwin says. "These things are imploding and exploding, and you have to track the fluid mechanics with the precision of a Swiss watch." Every time a component is changed or upgraded in a U.S. nuclear warhead, the TSF virtually tests the bomb to make sure it will still go boom. The computer simulations have revealed aspects of nuclear fission that testers hadn't anticipated, and, consequently, the number and complexity of algorithms have increased over time. Modern simulations model only parts of a full explosion, and even then, the most complex sims Goodwin runs use about a million lines of code. If you had 1600 years, the calculations could conceivably be done on a laptop; Livermore's current 500-teraflop Blue Gene/P system, named Dawn, gets a high-complexity sim done in a month. When the 20-petaflop Sequoia system goes live in 2012, the test time should drop to a week.

TO UNDERSTAND SUPER-computers, you need to understand flops, or floating-point operations per second. Flops are essentially math with decimals, as opposed to integer calculations, which require whole numbers. When it comes to hardcore number-crunching, flops are more data-efficient than integers—consider Avogadro's number, expressed as 6.02×10^{23} , compared with its integer alternative, which would fill out most of this sentence. High-performance computers are super-floppers: Sequoia's 20 petaflops equals 20 *quadrillion* calculations per second.

trades that drove the Dow down 600 points in 5 minutes.

The secret to supercomputing is parallel processing. The design of a supercomputer allows the machine to break up a task—say, predicting the path of a tornado—into lots of interdependent calculations, then groups of processors crunch the numbers all at once. To make things even faster, each of Sequoia's chips has onboard networking and can share data directly with any other chip in its rack.

It's a brute-force approach to math, and it is surprisingly powerful. A Blue Gene/P computer recently cal-

The logic for building supercomputers is strikingly similar to that of nuclear deterrence. **We must have more computing power than our competitors or they will use their technological superiority against us.**

So high-performance computing is predicated on the idea that many of the world's most complicated problems are ultimately reducible to pure math. And those problems range from matters of national security (the viability of Goodwin's nukes) to day-to-day concerns (predicting the weather this weekend—and the weekend after that). Not only are supercomputers routinely used in research (climate modeling, gene sequencing, artificial intelligence), but they are also becoming essential to commercial enterprises such as drug development, oil exploration and aircraft and automotive design, as well as product R&D. For example, Arizona-based Ping has used Cray supercomputers to aid in golf-club design. Supercomputers let companies speed products through the development cycle by virtualizing much of the design and testing. High-performance computing can also have more ominous consequences—Wall Street's "flash crash" in May 2010 was caused by a chain reaction of HPCs making high-frequency

culated pi to the billionth digit. It's also surprisingly scalable. Sequoia will have 96 racks, but Dr. George L.T. Chiu, one of IBM's top HPC scientists, claims that with a few simple hardware and software changes, Blue Gene/Q could theoretically support up to 32,768 racks, with an estimated compute power of 6848 petaflops. "The actual limit is the dollars you're willing to spend," Chiu says. "And, of course, you have to have the power."

Oh, yes, electricity. That's the other big issue with HPCs. Sequoia will be the most powerful supercomputer in the world, but it will also be one of the most power-hungry. At peak load, Sequoia is expected to operate at 9-plus megawatts, enough to power more than 7200 homes. It turns out, however, that Sequoia will also be the world's most power-efficient computer, churning out 2 gigaflops per watt. By comparison, the K Computer in Japan, which operates at 9.9 megawatts, puts out just 800 megaflops per watt—accomplishing only 40 percent of the calculations with the same electricity. But like processing power,

electricity use scales linearly as you add racks to a supercomputer. If you double the racks on Sequoia, you get a computer that's twice as fast—but you also get a computer that's twice as power-hungry. Being the world's most efficient computer helps to mitigate that consumption, but only to a point.

CHINA ISN'T THE ONLY COUNTRY aiming for exascale. The Department of Energy deems it critically important to American technological competitiveness, and companies such as Intel and Nvidia are promising exascale performance by the end of this decade. It's a technological challenge that goes beyond mere improvements in processing power. "To build exascale you have to have a vision of what applications will look like 10, 15 and 20 years from now," says Dave Turek, IBM's vice president of exascale computing. Turek and his contemporaries foresee a future where the volume and speed of data coming at machines like this will be several orders of magnitude higher than it is now, and will require a ground-up re-engineering of some of the fundamentals of computing, such as data storage, networking, software and power systems.

Supercomputing is an expensive hobby for a nation to have. The DOE puts the combined development costs of Sequoia and Blue Gene/P Dawn at about \$250 million. Plus, the annual electric bill to operate a petascale computer runs \$5 million to \$10 million. High-performance-computer scientists know that costs like these can't be allowed to scale along with the gains expected from exaflop

machines. But Goodwin and others in his field see these computers as essential. He points out that China's government has a stated goal of using supercomputers to gain an industrial edge, and we should be doing the same. "We can do all of the engineering 'what ifs' on a supercomputer and bring a product to market five times faster than when you actually had to make things to see if they worked," he says. "Think about what it means to the national economy if Boeing, General Motors or General Electric can get to market in months instead of years. It matters, and if someone can get there five times faster than you, you're going to go out of business."

We justify the expense of these machines today because they help to maintain our nuclear stockpile, but the logic for building them in the future is strikingly similar to that of nuclear deterrence itself. We must have more computing power than our competitors or they will use their technological superiority against us. This made me wonder what kind of computer would be fast enough for Goodwin's 50-microsecond nuclear sims. I asked him: If a 500-teraflop computer could do it in a month, and a 20-petaflop computer could do it in a week, could an exaflop computer do it in real time? "An exaflop machine is way too slow to run such a simulation in real time," he answered via email. He told me a real-time nuclear simulation would require a 100-yottaflop computer—that's 100×10^{24} calculations per second, 100 million times faster than an exaflop machine. Another floating-point operation. **PM**

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This Is My Job

✕ FABRICATOR

Name: THOMAS HOSFORD
Location: ANN ARBOR, MICH.
Age: 28
Years on Job: 14

✕ **A busted clutch drove Thomas Hosford** to a job that turned out to be his calling. It was 1998, and "my time was cheaper than buying a new clutch basket," he says. So he headed to his father's fab shop—which the elder Hosford has operated since 1979—and milled a new part from an aluminum slab. After that, Hosford worked summers alongside his dad, but didn't realize he wanted a fabricating career until he studied business for two years at Indiana University. "I found myself going back to the shop every chance I could," he says. Now, Hosford can make just about anything. "I'm either fixing a cracked lawnmower deck or making parts for remotely operated vehicles [ROVs] that maintain underwater pipes." His bike frames in particular are getting noticed. Demand is so great that he started a side business, Ordinance Bikes, to build custom downhill MTB and BMX frames. — LARRY WEBSTER

HOW TO FAB A CUSTOM PART:

DESIGN VERIFICATION

→ Jobs arrive with a variety of instructions. Most are singular requests, like the coupler (left) that connects an underwater ROV's cable to the control unit. "Sometimes a guy wants a real-life version of a napkin sketch," Hosford says. "Other times I get detailed CAD drawings." In all cases, he checks to see if the part can actually be made. "I look for tricky curves or oddly placed holes, and I'll work with the customer to simplify the design to reduce the labor cost."

FABRICATION

→ While Hosford works with all types of metal, wood and composites, the coupler plans called for corrosion-resistant bronze. First, Hosford cut a solid, round bar of bronze to the specified length. Next, he bored a central hole with a lathe, then used a milling machine to cut a groove down the coupler's length and to drill and tap the perpendicular holes. Milling machines—the backbone of every fab shop—use a variety of cutting and drill bits that rotate in a spindle like a drill press. But the table on a milling machine moves in three dimensions while the spindle stays fixed. The material, which is rigidly held in place by fixtures, is moved to engage the bit.

FINAL INSPECTION

→ As he does with everything he fabricates, Hosford used a die grinder to clean burrs off the coupler. He also polished any machining marks and measured the part to make sure it matched the plans. Then it was off to the customer—and on to the next job for Hosford. "Every day is different," he says. "I love the variety."



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